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A ROCK CRUSHER OF 800 TONS PER HOUR CAPACITY.*

By RICHARD BERNHARD.†

The accompanying illustration shows an exterior view, and Fig. 2 is a sectional elevation, of the largest stone crusher in existence. This crusher is operated by the Dixie Portland Cement Co. at South Pittsburg, Tennessee, and crushes all the rock used in its 4,000-barrel cement plant. The rock is an exceedingly hard and tough limestone and all of it is reduced by this crusher to 6-in. size and smaller.

FIG. 1. THE LARGEST STONE CRUSHER EVER BUILT.
VIEW TAKEN IN SHOPS OF THE POWER & MINING MACHINERY CO. OF CRUSHER FOR THE DIXIE PORTLAND CEMENT CO.

The stone is brought to the crusher in cars carrying 7,000 lbs., the loaded cars running down two tracks by gravity and being automatically dumped directly into the hopper by tipples. The empty cars are pulled back to the quarry with a small hoist operated by compressed air.‡

The rock crusher is 18 ft. 11 ins. high and weighs 425,000 lbs. The hopper is 20 ft. in diameter and fairly steep, to facilitate feeding the stone in from all sides by gravity. The spider which forms the top bearing for the shaft has but two arms and these do not obstruct the coarse rock from sliding in.

There are two receiving openings in the spider each 36 ins. wide and 138 ins. long, and pieces of rock as large as 3 ft. x 5 ft. x 10 ft. can be crushed by this machine to 6-in. size at a rate of 800 tons per hour; 60% of this product will be 4 ins. and smaller, and 30% will be 2 ins. and smaller.

The head and concaves, between which the rock is broken, are of chilled cast iron. The head is heavily corrugated so as to break up the stratified or slabby stone into smaller pieces. These corrugations also assist in crushing the large boulders, the ridges pulverizing the stone locally and causing it to split. The concaves are made in 54 pieces arranged in three rings, one above the other. These concaves are held in place with zinc which is poured behind and between them. Manganese steel concaves and a self-tightening manganese steel mantle for the crusher head are used with breakers crushing granite, quartz, trap rock and the hard and abrasive limestones. Still finer crushing can be accomplished in this mammoth breaker by using corrugations on the lower ring of concaves as well as on the head, as the flat pieces cannot pass through so readily without being broken by the interlocking ridges.

The top shell of the crusher is made in two pieces connected by fourteen 5-in. bolts shrunk in place on account of exceeding in size the limits of railroad transportation. Each half, with its concaves, weighs 57,000 lbs. The lower shell of the crusher is a single casting and weighs 73,000 lbs. The bottom plate, with bushing, gear and eccentric, weighs 38,000 lbs. The eccentric is surrounded by a large oil chamber which extends 3 ins. above the top of the bronze wearing ring that supports the gear and the eccentric. This insures cool running at all times, as the bearing is entirely submerged and the oil can circulate rapidly through the many and large passages and oil grooves in the bearing.

The gear is of cast steel, 4 ins. pitch, 12 ins. face and 7 ft. diameter. The driving pulley is 66 ins. diameter by 32 ins. face, and is without a safety device of any kind such as are used on the other gyratory crushers. The machine is so heavily proportioned that break pins are not necessary. Experience has also shown that all known safety pins are unreliable, breaking when no load is in the crusher, and again resisting rupture when the machine is damaged by clogging, etc.

The main shaft weighs 33,000 lbs. and is 30 ins. in diameter in the center. The crushing head is 65 ins. diameter on the bottom and 6 ft. 9 ins. high, and weighs 32,000 lbs. The shaft and head are suspended in the spider at the fulcrum point or point of no motion. The design for this crusher was based on an assumption of a crushing pressure near the bottom of the head of 1,500,000 lbs. Tests at South Pittsburg show that 29 HP. are required to run the machine empty, and the load when crushing varies between 56 and 153 HP. All of these figures include the friction of the motor. Granites and trap rock will probably take twice this power when reducing to 6-in. size. The power required is proportional to the rate and fineness of crushing, and in such instances where the mammoth machine is reducing the large rock to 8 ins. and 10 ins. size, for recrushing by other breakers, it can be operated at a lower speed and produce the same tonnage with correspondingly less power.

The heavy and expensive parts of the machine are protected by removable steel and white iron liners wherever abrasion takes place. This reduces the maintenance cost to a lower figure per ton of rock crushed than in the smaller crushers.

*A 250,000-lb. crusher of the same general construction, for the Little Falls Stone Co., was illustrated in our issue of May 3, 1906, and some particulars of the large crusher at the Dixie plant, shown herewith, were given in our issue of Sept. 19, 1907. The article herewith gives additional information.—Ed.

†Care Power & Mining Machinery Co., Cudahy, Wis.

‡The rock is shoveled into the cars by a 70-ton Marion steam shovel.

The construction of this machine is as simple as that of the smaller crushers, and but four extra pieces were necessary to make it possible to transport it over railroads.

Remarkable saving in the cost of producing crushed rock will be effected by this machine, not only at the crusher but also in the quarry. Where possible the rock can be drilled with a 4-in. or 5-in. well drill, the holes being placed from 20 to 30 ft. back from the breast and from 10 ft. to 20 ft. c. to c., with a depth of 50 ft. to 100 ft. When blasting is done in this manner, very large quantities of stone can be dislodged and broken up with a minimum expenditure for drilling and explosives. The stone is not scattered as much as when the blasting is done close up to the ledge and it is easier to shovel up the broken stone because the shovel does not have to be moved as often as when the rock is scattered. The crusher has such a large receiving opening that it is possible to bring to the machine pieces that had to be formerly sledged by hand or else drilled for pop shooting.

The operation of this large machine is not dependent upon labor to the same extent as the smaller crushing plants, because 75% of the labor is replaced by machinery. In view of this the chances for shutdowns on account of strikes, scarcity of labor at harvest time, etc., will be eliminated almost entirely. This large breaker has an enormous output for the investment in the plant, and this fact and the economies mentioned above will make it possible to produce all sizes of crushed stone at cost heretofore undreamed of.

Credit is due Mr. Leigh Hunt, president of the Hunt Engineering Company of Iola, Kan., as he first suggested building so large a gyratory crusher. Mr. Hunt also made a number of suggestions regarding the design which were incorporated in the crusher. The Dixie Portland Cement Co.'s plant was designed and erected by the Hunt Engineering Co.

This crusher was designed and built by the Power & Mining Machinery Co. of Milwaukee, Wis., and has been added to their regular line of ten sizes of McCully crushers.

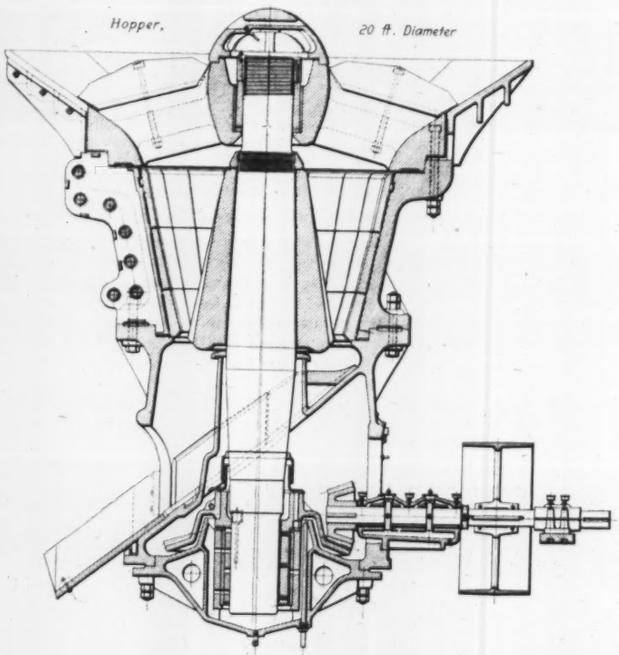


FIG. 2. SECTIONAL ELEVATION OF ROCK CRUSHER FOR DIXIE PORTLAND CEMENT CO.

THE PAMLICO SOUND SECTION OF THE EAST COAST INLAND WATERWAY.

By G. C. SCHERER.*

An inland waterway paralleling the Atlantic Coast was first considered among the prominent projects of the Board of United States Engineers for Internal Improvements during the administrations of Presidents Monroe and Adams. The first survey was authorized in 1837, for a route passing inside Capes Lookout and Hatteras, beginning at the southern end of the Dismal Swamp Canal, and ending at Winyah Bay, S. C. Subsequent plans changed the southern terminus to Beaufort Inlet, N. C. Numerous attempts have been made to determine the cheapest and most feasible route, and several estimates and recommendations have been submitted.

The distance from Norfolk, Va., to Beaufort Inlet by any possible land route is approximately 180 miles as opposed to a distance of 250 miles by sea. A large portion of this distance is covered by sounds and rivers accurately surveyed by the Engineer Department or the Coast and Geodetic Survey. The region through which the proposed waterway must pass is generally low, rarely attaining an elevation of over 20 ft. above tidewater. The most noticeable features of the topography of the area traversed are the low sand islands forming a perfect cordon that separates the sounds from the ocean, and the two large sounds, Pamlico and Albermarle.

The Act of Congress of 1907 provided for "Improving and Constructing Inland Waterway from Pamlico Sound to Beaufort Inlet, N. C.," for which the sum of $550,000 was appropriated under the continuing-contract system. This appropriation provides for what is known as the third division of the inland waterway from Norfolk, Va., to Beaufort Inlet, N. C.; the third division covers a distance of about 50 miles, from Pamlico Sound to Beaufort Inlet. On this distance a minimum depth of 10 ft. at low water is to be secured by dredging Adams and Core Creeks and constructing a canal of the same depth between the heads of these two creeks.

The length of that part of Division 3 upon which improvement is required is about 14 miles, about five miles being through dry land. The channel has its terminus in Beaufort Harbor. Its course is northerly from Beaufort, through Newport River and Core Creek to the head of the latter, thence through the intervening land to Adams Creek, and down Adams Creek to the 10-ft. contour in Neuse River. The dimensions of the channel, as given in the Report of the Board of Army Engineers upon which the Act of Congress making appropriation is based, are as follows:

	Bottom Width.	Side Slopes.
Excavation through dry land	90 ft.	1:2½
Narrow parts of rivers	125 ft.	1:3
Wide parts of rivers	250 ft.	1:3
Open sounds and across bars	300 ft.	1:5

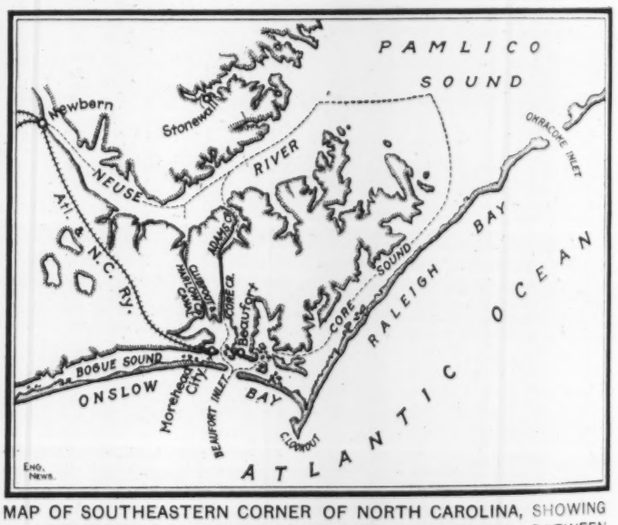
To construct this channel will necessitate dredging approximately 3,500,000 cu. yds. of material. The river and creek portions of the waterway will offer but the usual dredging problem, the material being thought to consist of soft mud, sand, clay, shell and silt; it is not thought that rock, large boulders or compact gravel will be encountered. The greater portion of the canal connecting Adams and Core Creeks lies through heavily timbered swamp.

There is now a navigable depth of ft. at low water in Adams Creek for approximately six miles from its mouth, and a depth of 11½ ft. at low water over the bar at the mouth of Core Creek on the Beaufort Inlet side. Core Creek is practically bare at low water.

The geographical situation of this waterway gives it a great commercial importance. It opens a safe light-draft navigation between important points in North Carolina, and other important points north; in fact, it completes a safe route from New York, via the Raritan & Delaware Canal and the Chesapeake Canal and connecting waters, to Beaufort Harbor, N. C., for light-draft craft, barges, etc. It is not easy, however, to arrive at any reliable conclusion as to the extent of the commerce which would be affected nor the amount of saving in freight charges.

Capes Lookout and Hatteras, especially the latter, have long been the terror of navigation. Before the introduction of steam, the passage around Cape Hatteras was extremely hazardous, and the Cape is still a serious menace to vessels. The records of the life-saving service for the past quarter of a century show that not less than $3,000,000 worth of property and 67 lives have been lost in the vicinity of Hatteras alone. It is estimated that 17% of the vessels trading along the coast are wrecked at this point. Further, vessels are frequently delayed in rounding the Cape, by conflicting winds and currents, even when the weather is not sufficiently stormy to be a source of danger. These delays are of such frequent occurrence that at different times it was seriously contemplated establishing a line of powerful tugs to assist delayed shipping. All of these dangers and delays have their effect on the cost of freight and insurance between northern and southern Atlantic ports.

Owing to the dangers and difficulties due to Capes Hatteras and Lookout, attempts to establish a barge system of transportation on the south Atlantic Coast have not proved successful, and the traffic continues to be carried in large sailing vessels and steamers. South of Beaufort, N. C., there is no very dangerous cape, and as the available harbors are quite numerous there is every reason to believe that opening of a waterway avoiding these capes would be shortly followed by the introduction of barge transportation, with a decrease in cost of freight and insurance.



MAP OF SOUTHEASTERN CORNER OF NORTH CAROLINA, SHOWING LOCATION OF DIVISION 3 OF INLAND WATERWAY BETWEEN NORFOLK, VA., AND BEAUFORT INLET, N. C.

In so far as was possible, an investigation of coastwise commerce was made in 1904, the matter being taken up with the commercial bodies

*U. S. Assistant Engineer, Wilmington, N. C.

of the various cities on or near the South Atlantic Coast. Based upon this investigation, it was estimated that the total commerce that would be affected by the entire waterway is about 2,700,000 tons, with an annual saving in freight of possibly $1,300,000. To what actual extent and at what rate this commerce would increase is a matter of speculation; but, judging from the effects of the opening of the canal between Lakes Superior and Huron, there is reason to believe that the development would be rapid.

The climate of North Carolina through which Division 3 passes is so mild that work may be carried on at all seasons of the year, an important consideration to prospective bidders on this work. There are ample dock facilities at Morehead City, within a few miles of the work, and no trouble is anticipated in moving and storing supplies. The labor problem will be unusually simple, as many of the inhabitants of the neighboring country are seafaring men, ready and willing to give up the uncertain livelihood of fishing in favor of more lucrative permanent work on the dredges and boats required in the construction of this waterway.

Within a short time bids will be mailed for this section of the waterway.

A SIMPLE TRACK INSPECTING AND RECORDING MACHINE.

With the increase of loads and speeds in railway service it is increasingly important to maintain the track in condition for the smooth and safe running of trains. Track inspection cars with apparatus for recording variations in line, level and gage, etc., are in use to a limited extent, but are too large and costly for general use. Attempts have been made to devise an apparatus which could be applied to an officer's car to indicate approximately the condition of the track, but very little progress has been made in introducing such devices. Mr. D. J. Whittemore, M. Am. Soc. C. E., Chief Engineer of the Chicago, Milwaukee & St. Paul Ry., devised an instrument which could be mounted in a car and would show the difference in elevation of the rails by the difference in level of the liquid in the legs of a U-shaped tube. The Chicago Great Western Ry. has used an instrument mounted in a car and indicating rough spots in the track. This was designed by Mr. C. A. Stickney several years ago. A stylus or needle marked a traveling sheet of paper at each point of bad line or surface; three needles were used, two for variations to right or left of the correct line, and the third to indicate variations from the correct level or surface. The frame of the machine carried three horizontal flat steel blades or straps, each having one end attached to the frame and the other end free; the free end of each blade was fitted with a weight and a contact piece. The two blades for indicating lateral movement were set on edge, while the blade for vertical movement was set flat. A lurch or swing of the car would cause one or other of the blades to make contact with a fixed stud, completing an electric circuit and operating the needle. The results were good when a uniform speed was maintained, but were not reliable with very fast or very slow running.

A machine simple and inexpensive enough to be furnished to division officers, and yet reliable enough to give practically useful results, is very desirable. A machine of this sort is now being introduced, and is an automatic inspector and recorder of track conditions. It can be used as a part of the roadmaster's or division engineer's equipment. It is the invention of Mr. T. Ellis, Roadmaster of the Northern Pacific Ry. at Tacoma, and the patents have been leased to the Railway Automatic Track Inspector Co., of Tacoma, Wash. It is in actual service on the Buffalo & Susquehanna Ry., and on the Pacific Division of the Northern Pacific Ry.

FIG. 1. A SIMPLE INSPECTING MACHINE FOR RECORDING IRREGULARITIES IN RAILWAY TRACK.

The machine, which is shown in Fig. 1, resembles a three-wheel track velocipede, and in use it is coupled behind a hand-car or inspection car. It weighs about 200 lbs., and can be run at any speed up to about 12 miles an hour. On a continuous roll of paper it draws a diagram showing the condition of the track as to surface, and if the rails are level on tangents and have the proper superelevation on curves. It also records low joints (showing the amount of the depression), and all variations from the proper gage. On the machine is a wheel exactly 3 ft. in circumference, which is connected to a cyclometer and is used in making measurements. The lineal scale of the diagram is 200 ft. to the inch, or 26.41 ft. to the mile; the natural scale is used for the gage, and half the natural scale for the elevation. Figs. 2 and 3 show portions of diagrams made on the Northern Pacific Ry., and representing good and bad conditions of track.

The driving gear moves the paper over the roll at the rate of 26.41 ins. per mile of track. A pendulum suspended from the vertical frame moves to right or left as the wheel on either side goes higher than the other, thus moving one stylus to right or left. The paper has a heavy ruled line upon which the stylus follows when the track is perfectly level, and marks to the right or left of this line show how much the track is out of level or what is the amount of elevation on curves. The paper is ruled with lines ¼-in. apart. A record of the gage is obtained by using two pieces of tubing for an axle, one piece being large enough to admit the smaller piece. Inside the large tube is placed a graduated spring which keeps the wheel flanges tight against the rails. The rod attached to the loose end of the axle carries the stylus which comes in contact with the paper and marks every change. A heavy line ruled on the paper shows where the stylus should be at standard gage. The distance that the diagram drawn by the stylus varies from this line shows how much too wide or narrow the gage is at any point.

The roll of paper is enclosed in a watertight box, so that the machine can be used in any kind of weather. One roll holds the paper before it passes over the driving roll under the stylus, while a receiving roll winds up the paper as the diagram is traced. A carbon belt runs outside all the rollers and directly under the stylus in contact with the paper. Thus the use of ink or pencils is obviated. A corrugated roller which presses on the carbon belt leaves an impression on the paper which comes out from under roller ruled. This obviates the necessity of having paper specially ruled for the purpose. Any paper that is the correct width can be used in this machine, or a transparent paper can be furnished if required for blue printing. The rollers carry sufficient paper for 50 miles of line.

A study of the diagram will enable the engineer or roadmaster to ascertain the condition of the track as a whole, and to see the several points which need attention. Thus spreading track, which is frequently assigned as a cause of derailment, can be detected, for (as a rule) this defect occurs gradually and would show as an abnormal widening of gage. Irregular line and elevation on curves are also at once detected, and such irregularities may seriously affect the safety and easy-riding qualities of the track. Blue prints can be made, and a print of each section sent to the section foreman, with notes and instructions as to bad places and the necessary work of improvement.

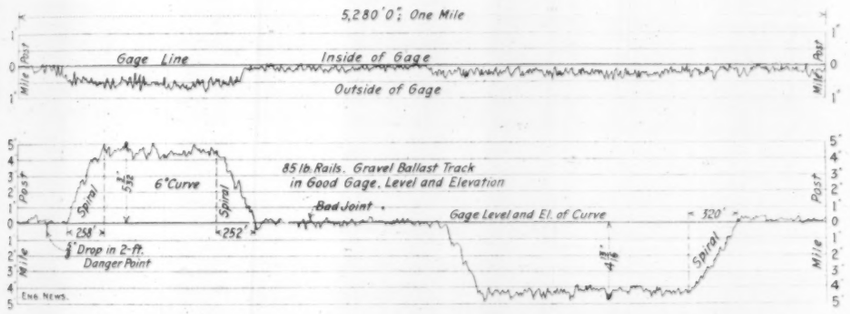


FIG. 2. DIAGRAMS MADE ON GOOD TRACK BY THE INSPECTING MACHINE.

A SLIGHT DECREASE IN IDLE FREIGHT CARS is recorded for the first part of May, by the Committee on Car Efficiency of the American Railway Association. On April 29 there was a surplus of 413,605 cars, while on May 13 there were 404,534. This last figure still remains much larger than the figure for any month or semi-monthly period prior to April 29 since the beginning of the present surplusage, last October. Box cars and coal cars share about equally in the improvement in the first two weeks of May.

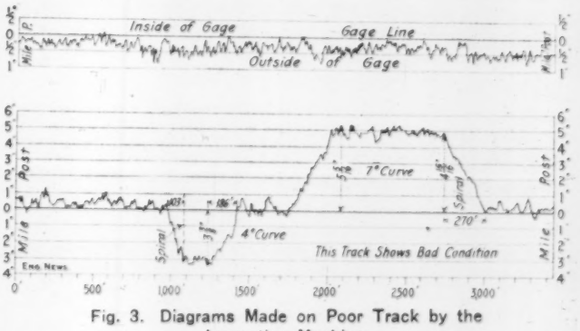


Fig. 3. Diagrams Made on Poor Track by the Inspecting Machine.

STANDARDS OF TRACK CONSTRUCTION ON AMERICAN RAILWAYS.

During the past few months we have instituted an inquiry as to the standards of track construction on a large number of railways, including some lines of the smaller class as well as the larger railway systems. The results are presented in the accompanying tables, compiled from special returns furnished by the engineers of the various lines. We are indebted to them for the completeness of the information which we are enabled to present. These tables represent pretty clearly the character of construction now adopted, and applied in new construction and renewals. At the same time it must be remembered that a great mileage of track of lighter construction exists on the railways mentioned, not only on their branches and secondary lines, but also in the tracks of their main lines. The 59 railways in the list comprise nearly 154,000 miles of line, of which 15,000 miles are represented by the two leading railways of Canada.

On the Michigan Central Ry. so many forms of rail joints are in use for experimental purposes that they require a separate supplementary table to themselves (Table V). With this exception all the information has been given in the main tables. This railway is considering the advisability of increasing the number of ties to a rail length. The number will be variable, so that in all cases the rail will be supported by the ties for a certain percentage of its length. It may be noted, also, that the Virginian Ry. is a new line of substantial construction, built to carry a heavy coal and freight traffic. Only about half of this railway has been completed.

The tables speak for themselves without further explanation, but in another column we have reviewed the information thus presented in detail.

THE EFFECT OF FLOORING PLANK IN DISTRIBUTING CONCENTRATED LOADS.

The extent to which the distributing action of floor plank relieves the stringers under them from the full effect of concentrated loads of loading was discussed at some length by Mr. Louis Ross in our issue of April 23, 1908, pp. 445-446. The same problem had previously been studied experimentally by E. L. Thomas and Clifton Ware as a thesis subject for graduation in Civil Engineering at the University of Nebraska in 1904. Several model floors were built and were then subjected to load in a testing-machine, the deflec-

TABLE I.—STANDARD PRACTICE AS

No.	RAILWAY	Miles	RAIL: Weight per yard. Lbs.	RAIL: Length. Ft.	RAIL: Type of Section	RAIL: Lightest in main track (exc. branches) Lbs.	RAIL JOINTS: Type	RAIL JOINTS: Square or Broken	RAIL JOINTS: Number of Bolts
1	Atchison, Topeka & Santa Fe	6717	85	33	A. S. C. E.	35	Suspended and Bridge	Broken	4 (4 on patented; 6 on angle bar)
2	Baltimore & Ohio	3495	85 to 100	33	A. S. C. E.	60	Suspended and Bridge	Broken	4 and 6
3	Bangor & Aroostook	521	85	33	A. S. C. E.	70	Suspended and Bridge	Broken	4 (Harvey)
4	Buff. & Lake Erie	216	100	33	A. S. C. E.	100	Suspended	Broken	6
5	Boston & Albany	392	100	33	Dudley	95	Supported	Broken	6
6	Boston & Maine	2288	85	33	A. S. C. E.	72	Bridge	Square on tan.; Broken on curves	4 (Harvey)
7	Buffalo & Susquehanna	382	80	33	.....	80	Suspended	Broken	4 (Harvey)
8	Buffalo, Rochester & Pitts.	558	90	33	A. S. C. E.	80	Bridge	Broken	4
9	Canadian Pacific	9425	80, 100	33	A. S. C. E.	72	Suspended	Broken	4 (Harvey)
10	Central of New Jersey	646	90	33	A. S. C. E.	Some 70	Suspended	Broken	6
11	Chicago & Alton	989	80	33	A. S. C. E.	80	Suspended and Bridge	Broken	6
12	Chicago & East. Illinois	823	85	33	A. S. C. E.	60	Suspended and Bridge	Broken	4
13	Chicago & Northwestern	7363	90	33	A. S. C. E.	60	Bridge	Square on tan.; Broken on curves	4
14	Chicago, Burlington & Quincy	9023	85	33	A. S. C. E. but with sloping sides to head	75	Suspended and Bridge	Broken	4 (4 on patented; 6 on angle bar)
15	Chicago, Ind. & Louisville	592	75	33	A. S. C. E.	75	Suspended	Broken	4
16	Chicago, Milwaukee & St. P.	7186	85, 100	33	A. S. C. E.	60	Bridge	Broken	4
17	Chicago, R. I. & Pacific	7393	85 (100 Chicago Term. Division)	33	A. S. C. E.	65	Suspended and Bridge	Broken	4
18	Chicago Great Western	1367	85	33	A. S. C. E.	75	Bridge	Broken	4
19	Cincinnati, Ham. & Day	1038	85	33	A. S. C. E.	66	Suspended and Bridge	Broken	4
20	Cincinnati, N. O. & T. P.	338	85	33	A. S. C. E.	75	Suspended and Bridge	Broken	4
21	Cl., Cin., Chi. & St. Louis	1939	90	33	A. S. C. E.	80	Suspended and 3-Tie	Broken	4 (6, 90-lb.; 6, 80-lb.)
22	Delaware, Lack. & Western	957	90	33	A. S. C. E.	80	Suspended and Bridge	Broken	6
23	Denver & Rio Grande	1822	85	33	D. & R. G.	75	Suspended	Broken	4
24	Duluth & Iron Range	161	80, 100	30, 33 (33 pref'd)	A. S. C. E.	80	Suspended (and expts. with bridge plate)	Broken	6 (ordinary bar; 4 Samson bar)
25	Erie	2169	90	33	A. S. C. E.	74	Suspended	Broken	4
26	Florida East Coast	500	70, 90	30	A. S. C. E.	70	Suspended and Bridge	Broken	4 (Harvey)
27	Fort Dodge, Des M. & So.	85	70	33	.....	70	Suspended	Square on tan.; Broken on curves	4
28	Georgia	307	80	33	.....	65	Suspended and Bridge	Broken	4
29	Grand Trunk	4644	100	33	A. S. C. E.	79	Suspended	Broken	4
30	Great Northern	6168	85	33	G. N. Ry.	68	Suspended and Bridge	Broken	4
31	Hocking Valley	346	90	33	A. S. C. E.	67	Suspended	Broken	4
32	Illinois Central	4371	85	33	A. S. C. E.	70	Suspended, Bridge, 3-Tie	Square on tan.; Broken on curves	6 with 40-in.; 4 with 24-in.
33	Kansas City Southern	762	85	33	Mo. Pacific Ry.	60	Suspended and Bridge	Square on tan.; Broken on curves	4
34	Lake Shore & Michigan So.	1520	100	33	A. S. C. E.	80	Supported	Broken	4 on 80-lb.; 6 on 100-lb.
35	Lehigh Valley	1434	90	33	A. S. C. E.	80	Suspended	Broken	6
36	Louisiana & Arkansas	226	75	33	.....	60	Suspended	Square on tan.; Broken on curves	6
37	Louisville & Nashville	4349	80	33	A. S. C. E.	70	Suspended	Broken	6 (4 for 70-lb.)
38	Michigan Central	1745	100	33	A. S. C. E.	80	Supported, Susp., Bridge	Broken	4 and 6
39	Missouri Pacific	6479	85	30, 33	Mo. Pacific Ry.	63	Suspended	Sq. on tan. ov. 1000 ft.; B. on curves and short tans.	4
40	Nashville, Chatt. & St. Louis	1212	80	33	A. S. C. E.	58	Suspended and Bridge	Broken	6
41	New York Central	2829	100	33	Dudley	80	Supported (3-Tie)	Broken	6
42	New York, N. H. & H.	2057	100	33	N. Y., N. H. & H.	75	Suspended and Bridge	Broken	4
43	Norfolk & Western	1877	85	33	A. S. C. E.	67	Suspended and Bridge	Broken	6
44	Northern Pacific	5617	85	33	A. S. C. E.	56, 66, 72	Suspended and Bridge	Broken	4
45	Pennsylvania	5190	100, 85	33	Pa. R. R.	85	Suspended and Bridge	Broken	6
46	Pennsylvania Lines	2717	100, 85	33	A. S. C. E.	60 (little)	Suspended	Broken	6
47	Philadelphia & Reading	1488	90	33	A. S. C. E.	79	Suspended	Broken	6
48	Pittsburg & Lake Erie	191	90	33	A. S. C. E.	80	Suspended	Broken	4
49	St. Louis & San Francisco	4740	75 and 85	33	A. S. C. E.	40	Suspended and Bridge	Broken	4
50	St. Louis Southwestern	1451	75	30, 33	Car. S. Co. 75 D.	56	Suspended and Bridge	Square on tans.; Broken on curves	.....
51	Seaboard Air Line	2611	75	33	Dudley	58	Suspended is standard	Broken	4
52	Somerset	91	70 / 75	30 / 33	.....	50	Suspended and Bridge	Broken	4
53	Southern	7496	75, 80, 85	33	A. S. C. E.	75	Suspended and Bridge	Broken	4
54	Southern Pacific	5971	90	33	Dudley	62	Suspended and Bridge	Broken	4
55	Toledo, St. Louis & Western	450	75	33	A. S. C. E.	70	Suspended	Broken	4
56	Union Pacific	3092	90	33	Dudley	70	Suspended and Bridge	Broken	4
57	Virginian (200 m. open)	445	85	33	A. S. C. E.	85	Supported (3-Tie)	Broken	6
58	Wabash	2517	80	30	A. S. C. E.	70	Suspended and Bridge	Broken	4
59	Wisconsin Central	1022	85	33	A. S. C. E.	70	Suspended	Broken	4

tions of the several stringers being measured to give an index of the load distribution.

From a copy of the thesis of Messrs. Thomas and Wood, kindly sent us by Mr. Alfred Boyd, Instructor in Civil Engineering at Nebraska, the following brief report of this work is abstracted. The test floors were made up of stringers and floor-planks of clear yellow pine, all 3.56 ins. by 0.81 in. by 5 ft. long, the sticks being set on edge when serving as stringers and laid flat when used as floor-plank. The stringer spacing was varied in eight steps from 5.99 ins. to 10.62 ins., and the span-length of stringer in three steps from 46.2 ins. to 55.9 ins. The floors were erected in succession on a trestle frame carrying knife-edges on which the stringers bore by steel bearing-plates; three, five and seven stringers were employed in different cases, and notched end-spacing boards were used to fix the spacing of the stringers. Load was applied by a 200,000-lb. testing-machine through a calibrated series of levers. Ordinarily this was a central load, but in some tests two equal loads were applied, one to either of the stringers next the middle one.

The experiments were in each case made with (1) floor-plank loose and (2) floor-plank nailed down. In the former arrangement, of course, only the plank carrying the concentrated load will deflect with the floor, and only this one plank therefore has any load-distributing effect. The experimenters consequently used only a single plank in the loose-floor tests. In the nailed-floor tests, on the other hand, about three-quarters of the length of the test floor was covered with plank, a 6-d. wire-nail being driven at each intersection of stringer and plank. In the nailed floor, of course, the deflection of the loaded stringer pulls down all the attached planks and causes each of them to bear down on the adjoining stringers, so long as the nails hold.

The distributing action of all the floor-plank in the nailed floor results in relieving the loaded stringer by a distributed but non-uniform upward pull, greatest at the middle plank and least at the end planks, superimposed on the concentrated downward load; the adjoining stringers are loaded with a non-uniform distributed downward load, without a concentration. Thus the distribution of loading is different for the loaded stringer and the other stringers. In the case of loose floor, the loading is of the same kind for all stringers, being central concentrated loading, wherefore the load percentages for the several stringers are exactly proportional to their de-

TO RAILS AND RAIL JOINTS

RAIL JOINTS

No.	Size of Bolts. Ins.	SPACING OF BOLTS ins.	ins.	ins.	ins.	NUTLOCK	NUTS	SPLICE BARS Length. Ins.	Weight per pair. Lbs.	Special or Patented Joints Used	
1	⅞	....	5	5	5	No nutlock	Square	.....	.....	Continuous, Weber, Wolhaupter	1
	⅞ x ⅝	5	5	5	5	No nutlock	Square	30	.....		
2	⅞ and 1	5½	4	4	4	National	Square on ⅝; Hex. on 1 in.	26	53½	Weber, Bonzano, 100% and Duquesne	2
3	⅞ x 4¼	....	6	5	6	....	Ideal nut	Square	24	.....	Weber, Bonzano	3
4	⅞ x 4¼	....	5	5	5	....	National	Hexagon	Plain 32, Duquesne 30	84, 94	Duquesne	4
5	⅞ x 4½	5.6	5.6	5.6	5.6	5.6	National	Square	36	80	.....	5
6	⅞ x 5½	....	6	6	6	....	Harvey nut	Square	24, Weber	80, Weber	Weber is standard	6
7	⅞ x 4¼	....	5 7/8	5 7/8	5 7/8	....	Harvey nut	Square	26	52	None	7
8	⅞ x 4½	....	7	6	7	....	Verona, National ⅜ x 7/8 inch	1⅛ in. Square	26	.....	Continuous is standard	8
9	⅞ x 4½	....	6½	5½	6¾	....	Harvey nut	Square	26	48	All abandoned	9
10	⅞ x 5½	5	4	4	4	5	National	1¼ in. Square	28	65	100% and Continuous	10
11	⅞ x 4½	4½	4½	4½	4½	4½	No nutlock	Square	29	60	Weber	11
12	1 x 4¼	....	6	6½	6	....	Verona tail	Square	26	53¼	Weber, Continuous, Wolhaupter and Bonzano	12
13	⅞ x 3½	....	6	6	6	....	Verona heavy	Square	26	50	None	13
14	1 x 4¼	5	5	5	5	5	Verona	Both	35⅛ for 75 lb., 24 for Cont.	64, 70	Continuous, Weber	14
15	⅞ x 4½	....	6	6	6	....	Verona	Square	24	50	None	15
16	1 x 4½	....	6	5⅞	6	....	Verona ⅞ x ¼	Square	25 for Patent, 24 for Angle Bar	66 and 81, 44 and 61	Continuous, Wolhaupter	16
17	1	....	6	6⅛	6	....	¼-in. spring nutlock	Square	26	52 (84 with bridge plate)	Continuous	17
18	⅞ x 4¼	....	6	6	6	....	No nutlock	Square	24	65	Continuous (standard), 100%	18
19	⅞ x 4¼	....	6	5	6	....	Verona	Hexagon	24	50	Weber	19
20	⅞	....	7	4	7	....	No nutlock	Square	24	48	Wolhaupter, Weber, 100%, etc.	20
21	⅞ x 4½ ⅞ x 4¼	7, 6	6	6	6	7, 6	Verona	Square	38 for 90 lb., 30 for 80 lb.	.....	None	21
22	⅞ x 4½	4¾	4¾	4½	4¾	4¾	Verona tail	Hexagon	30	52	Continuous	22
23	⅞ x 4¼	....	6	6	6	....	No nutlock	Square	26	52.2	None	23
24	⅞ for 80 lb., ⅞ for 100 lb.	6	5	4	5	6	Verona tail	Square for 80 lb., Hex. for 100 lb.	34 Ordinary, 24 Samson	63 for 80 lb., 87 for 100 lb.	Bonzano	24
25	⅞	....	4	7	4	....	Various	Square	24	52½	....	25
26	⅞ for 70 lb., ⅞ for 90 lb.	....	5	8	5	....	Ideal nut	Square	24	38 for 70 lb.	Continuous, Weber	26
27	⅞ x 4	....	5	8	5	....	No nutlock	Hexagon	24	36	None	27
28	⅞ x 4½	....	6⅝	6½	6⅜	....	National (extra wide)	Square	26	48	Continuous, Weber	28
29	1 x 5	....	6	6	6	....	Verona	Square	24	63	None	29
30	⅞ x 4	....	5½	5½	5½	...	No nutlock	Square	24	60	Continuous, Bonzano, Wolhaupter, 100%	30
31	⅞	....	4½	4¾	4½	....	National	Hexagon	24	... .	None	31
32	⅞	9	4½	4⅛	4½	9	Verona	Square	40 and 24	80 for 40-in.	Wolhaupter, Bonzano, Weber, 100%	32
33	1 x 4½	....	4⅛	5	4½	....	Verona improved	Square	24	45	Weber (on light rail)	33
34	⅞ x 4½ ⅞ x 4⅜	8	6	6	6	8	Verona	Square	80 lb., 24 100 lb., 40	46.08 52.55	None	34
35	⅞ x 4¾	4	4	4	4	4	National	Hexagon	28	60	100%, old style Bonzano	35
36	⅞ x 4¼	5	5	5	5	5	Harvey grip nut, Verona nutlock	Harvey; Square; Hexagon	32	55.50	Abbott	36
37	⅞	6	4⅛	4	4⅛	6	Verona	Square	29	59, 40 for 70 lb.	None to any extent	37
38			(See Table V)			Verona, National	.....		(See Table V)	Continuous, 100%, Wolhaupter	38
39	1 x 4½	....	5	5	5	....	Tail	Square (Hex. with heavy bars on light rail)	26	52	None	39
40	⅞ x 4½	5	4	4	4	5	Spiral ⅛-in., National	Square	26	62 (Continuous)	Continuous	40
41	⅞ x 4¼	5.6	5.6	5.6	5.6	5.6	Harvey grip nut	Square	36	80	None	41
42	⅞ x 4¾	....	7	5	7	....	Harvey grip nut	Square	24	62.75	Weber	42
43	⅞ x 4¼	5	5	5	5	5	Harvey grip nut	Square	30	61	Bonzano (many), Weber, Continuous, 100% and Wolhaupter on trial	43
44	⅞ x 4⅞	....	6	6	6	....	No nutlock	Square	24	49.6	Weber, Continuous and Wolhaupter on trial	44
45	1 x 6	6	5	4	5	6	Spring washer	Both	30	.....	.....	45
46	1 x 4¾	6	5	5	5	6	Verona	Hexagon	33	82 for 100 lb., 62 for 85 lb.	Bonzano, 100% and Duquesne	46
47	⅞ x 4¼	5	4	4	4	5	Excelsior, National	Square	28	62	Bonzano (old style), 100%, Duquesne	47
48	⅞ x 4½	....	7	4	7	....	Verona tail	Square	26	69	Duquesne, Continuous, 100%, Wolhaupter, Weber	48
49	1	....	6	6¼	6	....	Verona	Square	26	46.50 for 75, 43.75 for 85	None	49
50	.....	....	....	....	....	....	(Various arrangements of joints)		.....	....	Ward, Weber	50
51	⅞ and ⅞	....	6	6	6	....	No nutlock	Square	24	24 to 38	Weber, Bonzano	51
52	⅞	....	7, 5	7, 8	7, 5	....	No nutlock	Square	25 and 24	.....	Weber	52
53	⅞	....	7	4	7	....	Plain coil	Square	75 lb., 24 80, 85 lb., 26	75 lb., 44, 80, 85 lb., 53	Bonzano, Wolhaupter, Weber, Contin., Duquesne, Abbott	53
54	⅞ x 4½	....	5½	5⅜	5⅜	....	Verona	Square	27	80.6 (Continuous)	Continuous	54
55	⅞ x 4¼	....	5⅜	5¾	5⅜	....	Verona	Square	24	42.72	None	55
56	⅞ x 4¼	....	5⅜	5⅜	5⅜	....	Verona	Square	27	86 (Continuous)	Continuous	56
57	⅞ x 4¼	6, 5	6	6	6	6, 5	Harvey grip nut, Harvey grip nut	Square	38, 32	76, ...	None	57
58	⅞ x 4½	....	5	5	5	....	Verona	Square	24	L, 59, Bon. 56, Cont. 67	Bonzano, Continuous	58
59	⅞ x 4⅛	....	6	5	6	....	Improved	Hexagon	24	.....	New Bonzano	59

flections; thus, if the stringer next the middle one deflects half as much as the latter it will be carrying half as great a load. In the case of nailed floor such a proportion does not hold.

The primary purpose of the tests, of course, was to measure how much load was carried by the loaded stringer directly, and how much by each of the other stringers. But it would be exceedingly difficult to measure the loads of the several stringers, whereas the deflections at any stage of the test can be measured very easily. The difficulty arising from non-proportionality of relative deflections and loads in the case of the nailed floor is largely removed by the consideration that the loaded stringer [illegible] proportionate deflection, due to [illegible] distribution of its loading, than the [illegible] ers. Therefore, if the share of lo[illegible] the loaded stringer is taken equa[illegible] which its deflection bears to the [illegible] stringer deflections, the result is [illegible] as a larger [illegible] nature of [illegible] her string- [illegible] carried by [illegible] the part [illegible] um of all [illegible] ight over-

TABLE II.—STANDARD [illegible] RACTICE

No.	RAILWAY.	Wood, and where obtained.	TIES: Average life in main track. Years.	TIES: Cost. Cents.	TIES: Renewed for wear or decay mainly.	TIES: Length. ft.	TIES: Thickness.	TIES: Width. ins.
1	Atch., Top. & S. Fe.	Pine (Tex.), Fir (Ore) / Oak	.....	Treat., 52, 63; Unt., 40; / Oak (Chi.), 66	Wear	8		8
2	Baltimore & Ohio	W., burr and chest. oaks; wild cherry, bl. walnut, locust, mulberry. (Chestnut, white cedar and l-l yellow pine under special contract.) Mostly W. Va. and Ky.	.....	.....	Decay	8½ / 8½ / 8½		7 pole / 8 split / 8 saw
3	Bangor & Aroostook	Cedar mainly / Hemlock and pine	C. 10 / H. & P. 6	Cedar, 40 / Hem. 30	Wear / Decay	8	6	5 to 6
4	Boss. & L. Erie	W. oak (Pa. and W. Va.). Steel (145,000)	6 to 7	80 to 90 (deliv.)	.....	8½		8
5	Boston & Albany	Chestnut. Hard pine	C., 9; P., 6	C., 60; P., 85	Decay	8		7 to 12
6	Boston & Maine	Cedar (No. Maine, Canada) / Chestnut (South and N. Eng.)	4 to 10 / 5 to 9	C. 50 / Ch. (So.), 60; (N) 55	Decay	8		6
7	Buffalo & Sus.	Chestnut and white oak (Pa.) / Yellow pine (Ga.)	8 / 9	Ch., 45; W. O., 65 / Y. P., 85	Decay	8		8
8	Buff., Ro. & Pitts.	Oak (Pa. & W. Va.); Pine (So.)	O., 8; P., 8	O., 75; P., 85 to 90 at N. Y	Decay	8½		7
9	Can. Pacific	Cedar, tamarack, jack pine, hemlock and B. Col. fir.	.....	.....	Wear without t. p. / Decay with t. plate	8	6	6 to 7
10	Central of N. J.	White oak (So. and local) / Yellow pine (So.) / Chestnut (along line)	9 with, or 6 without tie plates.	W. O., 70 / Y. P., 81 / Ch., 47	Decay with and wear without tie-plates	8½	7	9 min.
11	Chicago & Alton	White oak, red oak (chi. of zinc), hard pine (Tenn., Mo., Ark.)	W. O., 7; R. O., 3 / H. pine 7	1st Cl., 66	Decay	8	6	8
12	Chicago & E. Ill	Red and black oak (treated)	10	.....	Decay	8	6	8
13	Chicago & N. W.	W. oak, cedar, treated hemlock	.....	.....	Both	8	6	8
14	Chicago, B. & Q	Mich. cedar, W. oak, burr oak from So. Ill. and Mo. Mtn. pine in Wyoming. (In future treated inferior hard woods.)	10 (untreated)	.....	Decay	8	6	8
15	Chicago, Ind. & Lo.	Oak varieties from So. Ind.	6	W. O., 56 to 72. / Oaks, 39; Ced., 70	Decay	8	6	8
16	Chicago, Mil. & St. P.	Cedar (Mich.); Oak (South) / Treated pine (Tex.)	C., 15; O., 8 / Not known	C., 65; O., 70	Decay	8	6	8
17	Chicago, R. Id. & Pac.	Various, from north and south	No good records	.....	Decay	8	6	8
18	Chicago Gt. West	Oak	10	Chic., 70; Kan. C., 68	Decay	8	6	8
19	Cin., Ham. & Day	W. and burr oak, chestnut (E. Ky., W. Va., So. Ohio).	O. & C., 10	O., 70; Ch., 65	Decay	8	6	8
20	Cin., N. O. & T. P.	W. oak (along line)	.....	.....	Decay	8½	7	9
21	Cl., Cin., Chi. & St. L.	W. oak (untreated) / Beech, red oak, gum (treated)	7 / Not known	75 / 85	Decay	8½	7	8
22	Del., Lack. & West.	Pine, white oak, chestnut	All 7	87½	Decay	8½	7	9
23	Denver & Rio G.	Native pine. Oregon fir	6	.....	Decay	8	7	8
24	Duluth & I. R.	Tamarack, cedar (along line)	T., 7½; Ced., 11 with tie-plates	T., 56; C., 64	Both	8	6 to 7	6 to 10
25	Erie	Yellow pine (So.)	8 to 10	.....	Decay	8½	7	9
26	Fla. E. Coast	Yellow pine (Ga. and Fla.)	5	51	Decay	8½	7	9
27	Ft. Dodge, Des. M. & So.	Oak (So.)	8	78	Decay	8	6	8
28	Georgia	Yellow pine (Ga.)	6	45	Decay	8	7	9
29	Grand Trunk	Cedar (Quebec) / Oak (Ky.)	8 / 12	41 (delivered) / 58 (delivered)	Wear / Decay	8	6	8
30	Great Nor.	Tamarack, cedar, fir, pine (Minn. Ida., Mont., Wash.)	6	40 to 65	Decay	8 / 8	7 / 7	7 pole / 8 saw
31	Hock. Valley	W. oak (Ohio, W. Va.)	6½	65	Decay	8½	7	9
32	Ill. Central	W. oak and cypress / Pine (Rueping process) / Red oak and chestnut (zinc-chlor.)	6 to 12	.....	Decay	8 / 8½ / 9	6 / 7 / 9	6 / 9 / 9
33	Kan. City So.	Oak (Okla., Ark., La.)	6	42	Decay	8	6	8
34	Lake Sh. & Mich. S.	W. Oak, chestnut, cedar	7 to 14	.....	Decay	8½	7	8, 9, 10
35	Lehigh Valley	Oak, pine, chestnut	O., 7; P. & C., 10	.....	Both	8½	7	9
36	Louisiana & Ark.	W. and post oak (La.)	5 to 6	27½	75% dec.; 25% wear	8	6	8
37	Louisv. & Nash.	Yell. pine, W. oak, post oak, cypress	7 to 10	35 to 50	Decay	8½, 9	7	9
38	Mich. Cen.	Cedar (Mich., Can.) switch ties, W. Oak	Cedar 12	C., 1st class, 48; 2d class, (24) S. ties, $25 per M. B.M. (U.S.)	Cedar, wear / Oak, decay	8	6 min.	6 to 10
39	Missouri Pac.	W. and red oak, gum, pine (Mo., Ill., Ark., La.)	.....	.....	Decay	8	6 / 7	8 / 9
40	Nash., Chatt. & St. L.	W., post and chest. oaks (along line)	Ave. 8	1st class, 40; 2nd., 20	Decay	8½	7	8 min.
41	New York Central	Oak, Yellow pine	8	80 to 90	Decay	8, 8½	7	9
42	N. Y., N. H. & H.	Largely chestnut; some oak, (local)	6	60 to 65	Decay	8	7	8
43	Norfolk & West.	W. and chest. oaks (along line)	8½ to 9	1st class, 49; 2d, 32	Decay	8½	7	7 min.
44	Nor. Pacific	Oak, pine, fir, tamarack, etc.	.....	.....	Decay	8	7	9
45	Pennsylvania	Oak, chestnut, yellow pine	7	O., 76; Ch., 52; Y. P., 85 / Miscell. 54	Both	8½	7 min.	7 min.
46	Penna. Lines	Oak (W. Va.)	10	75	Decay	8½	7	8
47	Phila. & Read.	Oak, pine, chestnut (90% from So.)	8	O., 75; P., 88	Decay	8½	7	9
48	Pitts. & L. Erie	W. oak	8	1st class, 82; 2d., 72	Decay	8½	7	8
49	St. L. & S. Fran.	W. oak (Mo., Ark., Ind. T.)	8 to 10	40 to 50	Decay	8	6	8
50	St. L. So. West.	W. and post oak, treated pine	O., 4; P., indef.	.....	Decay	8	6	8
51	Seaboard Air Line	Oak, pine, cypress (local)	P. & O., 7; C. 9	P. and cyp., 38 to 43 / O., 40 to 50	Decay	8, 9	7	9
52	Somerset	Cedar (along line)	9	36	Decay	8	6	8
53	Southern	Oak, pine, cypress, chestnut	W. oak, 8 to 10 / Red oak, 2 to 3 / P., 3 to 7	30 to 55	Both	8½	7	9
54	So. Pacific	Redwood, pine, fir (Cal., Ore.)	R., 5 (12 with t-p.) / P. & F., 6 (12 if treated & with t-p.)	.....	Redwood, wear / Others, decay	8	7	9
55	Tol., St. L. & West.	Red oak (Tenn.)	.....	60	.....	8	6	8
56	Union Pacific	Pine (treated), (Wyo., Tex.)	.....	Wyo. p., 50; Tex. p., 95 / (both treated.)	.....	8	7	8
57	Virginian	So. pine and oak	10	Aver. 60	.....	8	7	9
58	Wabash	W. and red oak (local and So.)	7	Ave. 50	Decay	8	6	8
59	Wisconsin Cen.	Hemlock, tamarack, cedar (local)	H., 5 to 6; T., 6 to 7 / Ced., 5 to 12	H. & T., 30 / Cedar, 40 to 45	H. & T., Decay / Cedar, both	8	7	7

estimate of the duty of the loaded stringer, which can at worst lead to designing the stringers slightly heavier than needed. The associated under-estimate of load percentage borne by the unloaded stringers is immaterial, as these values are not used for any further purpose. The error, in the case of the nailed floor, of assuming the load percentages to be proportional to the deflections, is, therefore, an error on the side of safety. However, it somewhat distorts the true ratios of strength of loose and nailed floors.

The floors were loaded in successive increments of 500 lbs., and the deflections of all stringers read at each step. For a given span and spacing of stringers, a single plank was laid loose across the middle and the full test made, keeping below the elastic limit of the stringers, however, as determined by preliminary tests. Then, upon removal of the load, the full set of floor-plank was put on and nailed down, and the loading program

AS TO TIES AND TIE-PLATES.

	TIES				TIE PLATES				
No.	No. per 30-ft. Rail.	Spacing at joints. ins.	Preservative process.	No. of treated ties in use.	Make.	Size. ins.	Weight. lbs.	Where used.	No.
1	18	.....	Rueping	12,205,000	Flat	6 x 8¼	6.10	Joints and curves	1
2	18	Varies with length or angle bar	None	None	Goldie, Hart	Varies with rail	Varies with rail	....	2
3	18	18 c. to c.	None	None	Goldie, Glendon	5 x 7½ x ⅜ (5 x 8½ joint)	....	Joints and curves	3
4	16	20 to 24 c. to c.	None	None	Goldie	6¼ x 8½ x ⅜ (6 x 8½ joint)	5.99 5.60	Only on curves	4
5	20	14½	None	None	Wolhaupter	.....	....	On curves	5
6	18 to 33-ft. 16 to 30-ft.	16	A few old creosoted and kyanized ties in side tracks.		Goldie	5 x 8 x ⅜	4.20	Curves of 4° and over	6
7	18	8 clear	.....	.....	Q. & W., Hardin	.....	....	Curves and soft ties	7
8	18	.....	None	None	Goldie	6 x 8 x 7/16	...	Curves and soft ties	8
9	18	10 for joint and shoulder ties.	None	None	Q. & W.	5 x 8¼ x 7/16	4	Joint ties, all soft ties, curves	9
10	18	19 c. to c.	Creosoting	31,618	Flat, shoulder	6 x 9(8 x 11 joint) ½ in. thick	6.5 & 11	All ties on curves, many on tangents	10
11	18	20 c. to c.	Zinc-chloride	.....	.....	....	....	On main track, on curves and H. pine ties	11
12	18 to 30-ft. 20 to 33-ft.	17½ c. to c.	Zinc-tannin	.....	Flat, with shoulder	8¾ x 6 ¼ x ⅝	6.7	Largely on soft ties; all ties on curves, bridges and turnouts	12
13	18 to 21 on tan. 19 to 22 curves.	17½ c. to c.	Zinc-chloride	.....	Glendon, etc.	8½ x 5	...	Curves and soft ties	13
14	19	17 c. to c.	Creosoting	.....	Sellers	6 x 8 track 7⅛ x 8 bridge	....	Curves and soft ties	14
15	18	16 c. to c.	Creosoting (beginning)	.....	Goldie, Wolhaupter	5 x 7⅛	4½	All soft ties, and all ties on curves of 3° and over	15
16	18	10 clear	Zinc-chloride and zinc-creo.	.....	Mall. iron flanged	5 x 8½ x 7/16	4	On all soft ties	16
17	18	18 c. to c.	Zinc-chloride; creosote	.....	C. R. I. & P. shoulder with flanges	6½ x 8¾ x ½	7	.....	17
18	20	16 c. to c.	None	.....	McKee	7½ x 5 x ⅜	....	Curves and soft ties	18
19	18	16 c. to c.	None	.....	Hart, Servis	5 x 8 x ⅜	....	Curves, soft ties with heavy traffic	19
20	20	19 c. to c.	None	.....	Goldie	.....	....	Only on curves	20
21	20	16 c. to c.	Creosote; zinc-creosote	1,500,000	McKee, Wolhaupter	5 x 8 x ⅜	....	Joints and treated ties under 100 lb. rail.	21
22	16 to 30-ft.	24 c. to c.	.....	3,000	Wolhaupter	4¼ x ⅜ (5 x ⅜ with shoulder)	....	On all curves	22
23	19	17 c. to c.	None	.....	Various	.....	....	Only on curves	23
24	130 lin. ins. per 30-ft. rail	Joints 66⅔% and shoulders 80% of body spacing	Wellhouse (experimental)	180	Servis, Wolhaupter	.....	....	On all cedar ties	24
25	18	20 c. to c.	None	.....	Goldie claw	5 x 8	....	On curves	25
26	16 to 30-ft.	8½ clear	Creosoting (experiment)	16,000	Shand	6 x 9 x ⅜	....	On creosoted ties only	26
27	17	8 clear	None	.....	None	.....	....	.....	27
28	18	17 c. to c.	None	.....	Goldie, Glendon	....	....	Experimentally	28
29	18	6 clear	Zinc-chloride for red oak	.....	Goldie, shoulder (no claws)	8 x 5 x ⅛	....	On cedar ties on curves, on oak ties on sharp curves, on switch leads and in yards	29
30	18	8 clear	Zinc-chloride	3,500,000	Goldie, Glendon	6 x 8	6	On all ties	30
31	17	8 clear	None	.....	Elyria, Goldie	5 x 7 x ⅜	....	On curves	31
32	20 for 33-ft. 18 for 30-ft.	Susp., 8 clear 3 tie, 10 clear	Creo. (Rueping), zinc. chl.	4,000,000	I. C. Std.; flat with shoulder	5⅛ x 8 x 7/16	....	On curves, on all pine and soft ties	32
33	22	.....	Zinc-chl.; creos. coating	.....	Fish-hook	5¼ x 8½ x ⅜	4.27	On curves and soft ties	33
34	18 for 100-lb. 17 for 80-lb.	17 c. to c.	None	.....	Single flange, with shoulder	6 x 8½ x ⅜, 100 lb. 6 x 8 x ⅜, 80 lb.	....	On jt. ties and curves	34
35	16	20 c. to c.	Creosoted	A few laid several years ago	Goldie, McKee, Wolhaupter	5 x 6 and 5 x 8½	....	Curves at pull-out points, yard leads	35
36	20 to 33-ft. 18 to 30-ft.	20 c. to c.	None	.....	Not used	.....	....	.....	36
37	16	19 c. to c.	None	.....	Goldie claw	6 x 7½ x ⅜	4.84	All ties on curves of 2° and over	37
38	18 (Note)	10 max.	None	.....	Wolhaupter, Green	5 x 9 x ⅜ and 5 x 8¾ x 7/16 (for 100-lb.)	....	All ties (except oak, and few of these left)	38
39	16 to 18	12	None	.....	Various	No standards as to tie plates			39
40	18	16 c. to c.	None	.....	Goldie	5 x 7½ x ⅜	4	On curves and all bridges, tans. where sand is used	40
41	20	14½ c. to c.	None	.....	Various	6 x 9 x ⅜	...	On all ties	41
42	18	19 c. to c.	Creosote	6-t. Har. Riv. bridge	Glendon (shoulder)	5 x 9 x ⅜	....	On all creosoted ties	42
43	18	17 c. to c.	None	.....	Wolhaupter, Glendon	5 x 8½ x ⅜ (9-in. at joints.	4.9, 5.5	All ties on curves of 5° and over	43
44	18	6 clear	Creosote (2 plants opened, 1907, 1908)	.....	Various	.....	....	On all ties	44
45	16	10 clear	None	.....	Pa. R. R. std.	7 x 9 x 7/16	....	On joint ties, curves, soft ties. Will be on all ties	45
46	18 (16 to 30-ft.)	10 clear	Burnetising mainly	40,000	Various	7 x 8¼ x ⅜ (7 x 7½ for 85-lb.)	....	On curves and where ties fail by mech. wear	46
47	18 (16 to 30-ft.)	19½ c. to c.	None	.....	Ph. & R.	6 x 9 (8 x 11 joint)	6.3, 10.6	All ties on curves	47
48	20	10 clear	None	.....	Goldie claw	6 x 8 x ⅜	5	Only on curves	48
49	18	18 c. to c.	Will try creosoting	.....	St. L. & S. F. std. flange & shoulder	6½ x 8¼	3	M. t. curves of 4° and over, m. t. turnouts, heavy switch tracks and where life of tie is limited by wear	49
50	18	.....	Wellhouse	.....	Malleable	5⅛ x 8	....	Alt. ties on 2° curves. All ties on curves over 2°	50
51	18 (16 to 30-ft.)	20 c. to c.	None	.....	Hart, Wolhaupter	5½ x ¼	....	Only on curves	51
52	20 for 33-ft. 18 for 30-ft.	20 c. to c.	None	.....	Glendon, Wolhaupter	....	....	Mainly on curves	52
53	16	18 c. to c.	None	.....	Hart, Goldie	5 x 8 x ⅜ (joint 6 x 8)	....	On oak ties on curves over 3° All pine ties in heavy m. track	53
54	18	16½ c. to c.	Burnetising (zinc-chloride)	8,000,000	So. Pac. std.	8 x 8¼	6.58	On all ties	54
55	20	8 clear	Zinc-chloride	845,550	Goldie claw	5 x ⅝	....	On curves over 6°	55
56	18	9 clear	Burnetising (zinc-chloride)	4,500,000	Flat bottom	8 x 8¾	6.58	On all ties except at joints	56
57	18	15¾ c. to c.; 6 clear	None	.....	Hart flat top	5 x 8 x ⅜	4	All ties on curves, and all soft ties	57
58	19	17 c. to c.	Zinc-chloride	50⅝ of ties	McKee shoulder	5 x 9½ x ⅜	4.3		
59	19	8 clear	None	.....	Plain, with shoulder	5 x 8	2.75	Only on curves and soft ties	58
					.....	5 x 8⅛	.....	Only on curves	59

repeated. The chief results of the tests are as follows:

With loose floor it was found, as is to be expected, that only three stringers share in the load, the plank lifting off the ones beyond. With nailed floor, tests were made using 5 and 7 stringers. It appears that all stringers receive a downward load, i. e., there is no reverse bending of the floor-plank. From the action of the loose floor, it would seem that the outer stringers in the nailed floor should receive an upward load. The discrepancy is not explained, but is probably due to the fact that the distribution of load along the stringers is different.

With nailed floor, the deflection of the middle stringers (and hence also the proportion of load carried by it) was liable to sudden increase, from some of the nails pulling out. Generally one nail starting would cause several others to follow, in quick succession.

The ratio of deflection of middle stringer of loose floor to that of a similar nailed floor was very close to 1.5 for all the tests, indicating that stringers in a nailed floor got something less than two-thirds as great a maximum concentration as stringers in a loose floor, so long as the nails hold.

Some of the floors were tested to failure, and it appeared that the nailed floors showed a ratio of ultimate strength to the similar loose floors somewhat greater than 1.5. But the results here were erratic, and in any case the increase of *ultimate* strength due to nailing down the floor-plank is of much less importance than the increase of strength within the elastic range.

When two concentrated loads were applied, one to each of the stringers next the middle one (the latter being unloaded), the deflection of the middle stringer was almost the same as that of the loaded stringers, and greater than its own deflection under a single central load equal to one of the two separate loads. This, most unfavorable, condition of loading might occur in a bridge floor if the stringer spacing were as large as half the spacing of the rear wheels of a traction engine, and the load-ratio for a single stringer would then be greater than that calculated for a single concentrated load. However, this test covered only one ratio of stiffness of plank and s[illegible]ger, and the conclusions therefore have no gene[illegible] validity.

Several floors with bridging b[illegible]een the stringers were tested. As compared [illegible] identical floors having no bridging, they [illegible] results slightly poorer. Tests carried to failu[illegible]ppeared to indicate that the weakening effect [illegible]ridging was chargeable to the nails drive[illegible]to the stringer. The only value of bridging [illegible]is concluded, is the sidewise stiffening wh[illegible]it produces; it gives no load-distributing e[illegible]

The tests of loose floor showed a [illegible]sion of load agreeing remarkably well with [illegible]e theoretical formula which Messrs. Thomas [illegible] Ware deduce:

Part of load borne by loaded stringer $= \dfrac{1 + 16 \dfrac{\text{Stiffness of stringer}}{\text{Stiffness of plank}}}{3 + 16 \dfrac{\text{Stiffness of stringer}}{\text{Stiffness of plank}}}$

in which the following is to be understood:

TABLE III.—STANDARD PRACTICE.

No.	RAILWAY	FROGS				
		Standard Pattern	Spring or Rigid	Nos. for Main Track	Nos. for Yards	Flangeway for Guard Rail Ins
1	Atchison, Topeka & Santa Fe	Riveted	Spring	9, 10	9	1¾
2	Baltimore & Ohio	Bolted	Spring on m. t. for slow speed turnouts	10 at passing sidings (16 if interlocked); 20 at ends of d. t.	8	1¾
3	Bangor & Aroostook	Clamped, Bolted	Both	8, 10	8 (some 6)	1¾
4	Bessemer & Lake Erie	Bolted (manganese steel center)	Rigid	10 (13 at ends of d. track)	8	.....
5	Boston & Albany	Plate, Bolted	Both	10	8	1¾
6	Boston & Maine	Bolted	Both	10	7, 8	1¾
7	Buffalo & Susquehanna	Bolted	Spring on main track	9	7	1¾
8	Buffalo, Rochester & Pittsburg	Plate, Bolted	Spring on main track	9, 12	7, 9	1¾ main track; 2 turnout
9	Canadian Pacific	Plate, Riveted	Spring on main track; Rigid at busy junctions	9	7	1¾
10	Central of New Jersey	Riveted	Both	8, 9, 10, 12, 15	9 (7 old)	1⅞
11	Chicago & Alton	Plate, Bolted	Spring	10	5 to 9	1⅞
12	Chicago & Eastern Illinois	Bolted (with plate)	Both	10, 12, 15	7, 8	1¾
13	Chicago & Northwestern	Bolted	Spring	10, 14	6¾, 7, 8	1¾
14	Chicago, Burlington & Quincy	Bolted	Spring on main track; Rigid on sidings	9 (11 for passing track)	7, 9	1¾, 1⅞ deep
15	Chicago, Indianap. & Louisville	Bolted	Spring	10	8	1⅞
16	Chicago, Milwaukee & St. Paul	Bolted	Spring in main track	10 (5° 44′)	8¼ (6° 45′)	1⅞
17	Chicago, Rock Island & Pacific	Bolted	Spring in main track	10 Sp. (15 rigid at juncts. and ends of d. t.)	6, 7, 8	1¾
18	Chicago Great Western	Combi. Plate and Bolt; Bolted (Rigid)	Spring in main track; Rigid	9 (15 at end of 2nd t. and passing tracks)	9 (some 7)	1¾ (2¼ on heavy curves)
19	Cincinnati, Hamilton & Dayton	Bolted	Spring in main track	10 to 18	6 to 8	2
20	Cincinnati, New Orleans & Tex. Pacific	Plate, Bolted	Spring	10, 24	7	1⅞
21	Cleveland, Cincinnati, Chicago & St. L	Bolted	Spring	10	8	1⅞
22	Delaware, Lackawanna & Western	Riveted plate	Spring on main track	10 to 20	8	1¾
23	Denver & Rio Grande	Riveted plate	Spring	8¾, 10	7, 8¾, 10	1¾
24	Duluth & Iron Range	Riveted plate	Both	10 Spring	8	1⅞
25	Erie	Clamped, Bolted, Plate	Both	10 and 16	7	1¾
26	Florida East Coast	Clamp. (Rigid) Keyed (Spring)	Both	8	6 and 8	1⅝
27	Ft. Dodge, Des Moines & Southern	Bolted	Rigid	9	7	1⅞
28	Georgia	Various	Spring m. t.; rigid in sidings	10	6 and 8	2
29	Grand Trunk	Plate, Bolted, Keyed	Spring in main track	10 Spring	7 Rigid	1¾
30	Great Northern	Bolted	Spring	11	9	1⅞
31	Hocking Valley	Bolted	Spring	10, 14, 20	8 Rigid	1⅞
32	Illinois Central	Riveted	Spring on straight track; Rigid on outside of m. t.	10 (15 for high speed turnouts)	7	1⅞
33	Kansas City Southern	Clamped, Plate, Riv., Bolted	Both	9	7	1¾
34	Lake Shore & Michigan Southern	Bolted	Some No. 10 spring, others rigid	10 at exit from passing siding and slow turnouts; 16 at entrance to pass. sid. and for train movts.; 20 at junction points	8	1¾ on tan
35	Lehigh Valley	Riveted and Plate	Both	10, 12, 15	7, 8, 10, 12	1⅞
36	Louisiana & Arkansas	Bolted	Spring	9	7	1⅞
37	Louisville & Nashville	Clamped	Both	9½ and 12	8	1¾
38	Michigan Central	Bolted	Spring, except at juncts. where turnout much used	11 (14 for high speed)	9	1⅞
39	Missouri Pacific	Plate, Bolted	Spring on main track usually	10 (22 for gantlet and high speed crossover	7 (Special cases full numbers)	1¾
40	Nashville, Chattanooga & St. Louis	Plate, Riveted	Spring (except yards)	9, 12	6, 7, 9	1¾
41	New York Central	Bolted	Both	19, 12, 18	7	1⅞
42	New York, New Haven & Hartford	Bolted	Both	10 and 15	6 to 10	1¾ on tan
43	Norfolk & Western	Plate	Spring where most traffic on main line	9 for m. l. sidings; 12, 15 for important turnouts with both sides equally used	7 mostly	1¾
44	Northern Pacific	Various	Spring in main track	9, 11, 12	7 and 9	1¾
45	Pennsylvania	Plated, Bolted (P. R. R.)	Both	8, 10, 15, 20	6 and 8	1¾
46	Pennsylvania Lines	Bolted	Both	10, 15, 20	7	1¾
47	Philadelphia & Reading	Bolted	Spring on main track	10 to 20	8	1¾
48	Pittsburg & Lake Erie	Bolted	Spring	10	8	1¾
49	St. Louis & San Francisco	Bolted	Both, and sliding wing	10	8	1¾ on tan
50	St. Louis Southwestern	Eureka Spring in main line		9	7 and 9	1⅞
51	Seaboard Air Line	Plate, Riveted	Spring	9	7	2
52	Somerset	Bolted and Riveted	Both	10	8	1¾
53	Southern	Bolted, Plate	Spring in main line	10	8 (also 7, 9)	1⅞ on tan
54	Southern Pacific	Bolted	Spring	10	6, 7, 9	1¾
55	Toledo, St. Louis & Western	Riveted	Spring	10	8	1¾
56	Union Pacific	Bolted	Both	10 Spring for m. t. turn; 14 Rigid ends of d. t.	6, 7, 9	1¾
57	Virginian	Clamped Plate	Spring on main track	10	7, 10	1⅞
58	Wabash	Bolted	Both	9, 20 (Spring)	7 (Rigid)	1⅞
59	Wisconsin Central	Bolted	Spring	10	6 and 7	1⅞

$$\frac{\text{Stiffness of stringer}}{\text{Stiffness of plank}} = \frac{\text{modulus of elast. of stringer}}{\text{modulus of elast. of plank}} \times \frac{\text{moment of inertia of stringer}}{\text{moment of inertia of 1 plank}} \times \left(\frac{\text{spacing of stringers}}{\text{span of stringers}}\right)^3$$

$$= \frac{E_s\, I_s}{E_p\, I_p} \cdot \frac{a^3}{l^3}$$

Mr. [illegible]'s formula (5), in our issue of April 23, 1908, p. 944, is identical with this one.

As already stated, the tests of nailed floors showed a value running quite regularly two-thirds of the above amount. The following empirical formula might therefore be written:

Part of load borne by Loaded Stringer in Nailed Floor =

$$\frac{1 + 16 \dfrac{\text{Stiffness of stringer}}{\text{Stiffness of plank}}}{3 + 16 \dfrac{\text{Stiffness of stringer}}{\text{Stiffness of plank.}}}$$

For stiffness-ratios varying from 0.02 to 0.20, these formulas give values which range roughly from 40% to 65% for loose floors, and from 25% to 40% for nailed floors; these percentages, of course, represent the part of the concentrated load which must be resisted by a stringer when the load is directly over the stringer.

The article of Mr. Ross, already mentioned, makes the assumption that when a concentrated load is halfway between two stringers, half the load goes to either of the two adjacent stringers. This is unquestionably true for loose flooring, so that in this case the stringer must in any event be designed for half the greatest concentration, even though the formula above shows a value below 50% for load directly over stringer. In the case of nailed floor, however, a load halfway between two stringers will undoubtedly be carried in part by the other stringers, so that those nearest the load receive less than 50%, perhaps approximately the value given by the formula for load over stringer. No tests for this position of load are included in the work of Messrs. Thomas and Ware.

An important showing of this work is that the nails pull out very easily, and the greater strength of nailed floor is therefore not much to be relied on. The pulling of nails appeared repeatedly in the tests within the elastic limit, while in the tests carried to failure it regularly led to failure at much lower load than would otherwise be expected. The authors suggest that a better fastening for timber bridge floors is worth consideration in order to maintain the nailed-floor condition under all degrees of loading and all kinds of traffic. Screws are suggested. In the case of continuous floor-joists across stringers in an all-metal floor, which is exactly analogous to the timber floor, the riveting or bolting will, of course, supply the required tensile resistance.

FIVE MILES OF SEWER were recently laid at Maplewood, N. J., under the supervision of Mr. Jameson, of Birmingham, England. Tarred jute was used instead of ordinary hemp and, although the pipe lies mainly in wet ground, the total leakage in the main outlet pipe, 10 ins. in diameter, was less than half an inch in depth.

AS TO FROGS AND SWITCHES

No.	SWITCHES: Standard Pattern	SWITCHES: Length of Switch Rail Ft.	Sharpest Turnout in Main Track Degrees	Auto. or Rigid Switchstand	Automatic Switch	Main Line Turnouts Protected by Distant Signals	Footguards for Frogs and switches	No.
1	Split	15	7° 30′	Rigid	.....	A few	Blocking	1
2	Split and Wharton	16½ (24 for No. 12 to 16, 30 for No. 20)	.....	Both	Some	.....	Steel Strap	2
3	Split	15 (some 10)	No. 8, 9° 30′; No. 10, 6° 00′	Auto.	No	No	Hart	3
4	Split	18	.....	Auto.	No	No	Metal	4
5	Split	15	10°	Auto.	No	Yes	Hart	5
6	Split	15	17°	Auto. for main track; Rigid for s. track	No	Yes	Hart	6
7	Split	15	.....	Auto.	No	No	.....	7
8	Split	18	.....	Auto.	No	Only facing points on d. t.	None	8
9	Split	15	9°	Auto.	No	Yes	Cast iron	9
10	Split	20, 30	11° 53′	Auto.	No	Yes	.....	10
11	Split, Wharton	15, 18	.....	Rigid	No	Partly	Hart (wood)	11
12	Split	15, 18, 24	9° 32′	Rigid	No	Yes	Wood block	12
13	Split	15	No. 10, 6° 5′	Rigid	No	Yes	Hart and wood block	13
14	Split	15	No. 9, 8° 50′	Auto.	A few in yards	Yes	Hart	14
15	Split	15	14°	Rigid	No	Two	None	15
16	Split	Std. 15; Special 24	6°	Rigid is standard; Auto. also used	No	Where view is obstructed	Hart (wood block)	16
17	Split	15 (24 for No. 15 frog)	7°	Rigid	No	Where view is obstructed	Hart or solid	17
18	Split	15 (24 for No. 15, 10 for No. 7)	8° 26′	Auto.	No	Some	18-in. cast iron block	18
19	Split	16½	No. 10	Rigid for high speed; Auto. for low speed and yards	On branches only	No	Wood	19
20	Split	18	.....	Rigid	No	All by el. auto. block signals	Wood	20
21	Split	16½	6°	Rigid	No	Partially	Cast iron	21
22	Split	15, 18, 20	14°	Both	No	Block signals on main line	None	22
23	Split	15	12°	Auto.	No	Some	Wood block	23
24	Split	18 for 80-lb. rail; 20 for 100-lb. rail	.....	Auto.	No	No	Wood (Hart on sp. rail frogs)	24
25	Split	15	.....	Both	No	Yes	Wood where law requires	25
26	Split	15	.....	Rigid	Abandoned	No	None	26
27	Split	15	12° 30′	Rigid	No	No	.....	27
28	Split	15	3°	Rigid	No	No	.....	28
29	Split	15	13.65°	Auto.	Abandoned	Some	Castings	29
30	Split	16½	10°	Rigid	No	Where dangerous	Flat blocks	30
31	Split	15 and 18	6°	Rigid	No	10%	Metal	31
32	Split	15	12° 26′	Rigid	No	In dangerous places	Wood block	32
33	Split	15 and 12	30°	Rigid	No	No	Wood	33
34	Split	100-lb., 16, 25, 30; 80-lb., 15, 25	No. 10, 7° 24′	Rigid	No	Facing, where not protected by automatic block signals	C. I. blocks at ends	34
35	Split	15 and 21	7° 33′	Both	No	Yes	Not usually	35
36	Split	15	7° 31′	Rigid (auto in yards)	No	No	.....	36
37	Split	10, 12, 15, 18	8° 19′	Both	No	Where view is obstructed	Metal	37
38	Split	15 (22 for high speed)	No. 9, 8° 18	Rigid (auto. in yards)	No	Block signal on main line; where nec. on branches	Cast iron, wood	38
39	Split, Wharton	15	.....	Both (auto. on main line)	Being removed	Signals being installed	Metal	39
40	Split	15	7° 30′ on tan.; 13° 30′ on cur.	Rigid	Yes; all	When not in plain sight for 2500 feet	Wood (where required by law)	40
41	Split	15	7° 06′	Rigid	No	Yes	Wood block	41
42	Split	15, 24	.....	Auto.	No	Where necessary	Hart (wood)	42
43	Split	15, 24	9° std., 14° max.	Auto.	No	No	Steel strap on edge	43
44	Split, Stub	15 (10, 15 yards)	7° 31′	Rigid	Few in yards	At crossovers and obscure turnouts	Wood	44
45	Split (few Wharton)	10, 18, 30	12° 34′	Both	No	Nearly all	Experimental	45
46	Split	18, 30	No. 10	Auto.	No	Where heavy traffic or view obstructed	Metal	46
47	Split	20 and 30 on main track; 15 yards	60 ft. rad.	Auto.	Yes, where auto. is st. not used	At bad places where no automatic block signals	None	47
48	Split	18	10°	Rigid	No	Automatic el. block signals	Lucas	48
49	Split	15 (24 for No. 15)	7°	Rigid	Some in yards	In special cases	Wooden	49
50	Split	15 for No. 9	7° 31′	Rigid	No	No	Wood in Missouri	50
51	Split (Wharton for special cases)	15	16° 30′	Rigid (standard)	No	No	Cast iron	51
52	Split	15	20°	Auto.	No	No	.....	52
53	Split, some Wharton	10, 15, 22	No. 10, 6° 45′	Both	No	Some	Wood block	53
54	Split	15	No. 10, 7° 10′	Auto.	No	Many	Wood	54
55	Split	15	8°	Rigid	No	No	Metal	55
56	Split	15 and 24	6° 6′	Rigid	No	Yes	Cast iron	56
57	Split	15	7°	Auto.	No	Where interlocked	None	57
58	Split	15, 24	7° 31′	Auto.	No	Where interlocked	Wood	58
59	Split	15	6° 6′	Rigid	No	Some	Hart	59

THE IMPROVEMENT AND EXTENSION OF THE SOUTH SIDE ELEVATED RAILWAY, CHICAGO.

While all railway improvement work that interferes with traffic is rendered difficult by the necessity of providing for the safe and prompt handling of trains over the work, exceptional difficulties are involved in such work on elevated railways. This is due both to the frequent service of trains and the limited space available for the workmen. The charged third-rail also introduces a serious danger. Extensive work of this kind has been carried out within the past three years on the South Side Elevated Ry., of Chicago, and was described in a paper read before the Western Society of Engineers on March 25 by Mr. J. N. Darling, the acting Chief Engineer, who has been in active charge of the work. The improvements included a third track over a long stretch of the line, changes of grade, reconstruction of stations, realinement of curves, and the building of new extensions. These were planned under the direction of Mr. C. V. Weston, M. Am. Soc. C. E., formerly Chief Engineer, and now President and General Manager of the railway. Mr. E. N. Wood, M. Am. Soc. C. E., was Principal Assistant Engineer while the work was being planned and during much of the construction. An abstract of the paper is given below, but as a preliminary to this we present some features of information which are not included or explained in the paper. The original construction of the railway was described and illustrated in our issue of Jan. 16, 1892.

The old structure has four lines of plate girders carried on two rows of columns spaced 12 ft. apart, each column having a flaring top to carry two girders 5 ft. apart. The spans are 35 to 60 ft. long. In the new construction, Fig. 1, for the additional track, the column is extended to the level of the tops of the girders, and has transverse web plates to which are attached the ends of the girders. This makes a more rigid and substantial construction. The new column is built up of a 15-in. I-beam between two 15-in. channels, the flanges of the latter being inward and connected by batten or tie plates riveted inside the flanges. The channels are transverse to the structure. In the old structure, each column had two 15-in. channels, set with the flanges inward and connected by lacing bars, the lacing being transverse to the structure. Where these old columns have been raised for changes of grade, however, the new bottom sections have two channels set back to back with the flanges outward and connected by batten plates, and these channels (like those of the new columns) are set transversely to the structure. These three arrangements are shown in Fig. 2, while the details of the new column are given in Fig. 1. The new transverse bracing between the columns is also shown in Fig. 2, this arrangement being used where the structure was raised sufficiently to give a minimum clearance of 14 ft. below the horizontal struts. Where the raise was not sufficient for the construction shown in Fig. 2, the transverse bracing was fitted only between the tops of the columns and was supplemented by new longitudinal knee-braces from the columns to the girders. This arrangement is shown in Fig. 3.

At first sight, it seems an easy matter to build an additional track, putting it alongside the existing structure. But in order to straighten the line, the widening was not made continuously along one side, and the adjustment and connections of the new and old structures involved considerable difficulties. Fig. 4 shows an example of this, the view being at 14th St., and looking northward. The right-hand track in the foreground is the new track, and runs into the old right-hand track at the curve; this latter track (now the middle track) is thus interrupted and disconnected, as shown. A new track has therefore to be built for a left-hand track at the curve; this will connect with the present left-hand track in the foreground, while the middle track will connect with the present left-hand track at the curve. Thus the old left-hand and right-hand

TABLE V.—RAIL JOINTS: MICHIGAN CENTRAL RY.

Rail wt. per yd. lbs.	Type of Joint.	Susp. or Supp.	Bolts.* No.	Bolts.* Diam. and length under head ins.	Spacing of Bolts. ins.	ins.	ins.	ins.	ins.	Bars. Wt. per pair. lbs.
100	38-in. angle bar	Supp.	6	1 × 5	8	6	4	6	8	95.8
100	25-in. angle bar	Susp.	4	1 × 5	..	7	4	7	..	64.8
100	100 per cent.	Susp.	4	1 × 5	..	7	4	7	..	73.0
100	Wolhaupter	Bridge.	4	1 × 5	..	7	4	7	..	....
80	44-in. angle bar	Supp.	6	⅞ × 4¼	9	6	6	6	9	76.8
80	38-in. angle bar	Supp.	6	⅞ × 4¼	7½	6	6	6	7½	65.2
80	25-in. angle bar	Susp.	4	⅞ × 4¼	..	6	6	6	..	46.9
80	23-in. angle bar	Supp.	4	⅞ × 4¼	..	6	6	6	..	....
80	Continuous	Bridge.	4	⅞ × 4¼	..	6	6	6	..	62.9
80	100 per cent.	Susp.	4	¾ × 4¼	..	6	6	6	..	....

*All bolts have square nuts.

TABLE IV.—STANDARD PRACTICE AS

No.	RAILWAY	SPIKES Style	SPIKES Size. Ins.	Screw Spikes Used
1	Atchison, Topeka & Santa Fe	Ordinary.	9/16 x 5½	Experiment
2	Baltimore & Ohio	Ordinary.	9/16 x 5½	Experiment
3	Bangor & Aroostook	Goldie.	11/16 x 5½	Experiment
4	Bessemer & Lake Erie	Ordinary.	9/16 x 5½	No
5	Boston & Albany	Ordinary.	9/16 x 5½	No
6	Boston & Maine	Goldie.	7/16 x 5	No
7	Buffalo & Susquehanna	Ordinary.	9/16 x 5½	No
8	Buffalo, Rochester & Pittsburg	Goldie.	.....	No
9	Canadian Pacific	Ordinary.	9/16 x 5½	No
10	Central of New Jersey	Ordinary.	⅝ x 5½	No
11	Chicago & Alton	Ordinary.	⅝ x 5½	No
12	Chicago & Eastern Illinois	Chisel point.	9/16 x 5½	On creos. bridge ties
13	Chicago & Northwestern	Ordinary.	9/16 x 5½	No
14	Chicago, Burlington & Quincy	Ordinary.	9/16 x 5½	Experiment
15	Chicago, Indianapolis & Louisville	Ordinary.	9/16 x 5½	No
16	Chicago, Milwaukee & St. Paul	Ordinary.	9/16 x 5½	No
17	Chicago, Rock Island & Pacific	Ordinary.	9/16 x 5½	To be tried
18	Chicago Great Western	Ordinary.	9/16 x 5½	No
19	Cincinnati, Hamilton & Dayton	Chisel point.	9/16 x 5½	No
20	Cincinnati, New Orleans & Texas Pacific	Ordinary.	9/16 x 5½	No
21	Cleveland, Cincinnati, Chicago & St. Louis	Ordinary.	9/16 x 5½	No
22	Delaware, Lackawanna & Western	Ordinary.	9/16 x 5½	No
23	Denver & Rio Grande	Ordinary.	9/16 x 5½	No
24	Duluth & Iron Range	Ordinary.	9/16 x 5½	No
25	Erie	Ordinary.	9/16 x 5½	No
26	Florida East Coast	Ordinary.	9/16 x 5½	No
27	Fort Dodge, Des Moines & Southern	Ordinary.	9/16 x 5½	No
28	Georgia	Ordinary.	9/16 x 5½	No
29	Grand Trunk	Ordinary.	9/16 x 5½	No
30	Great Northern	Chisel point.	9/16 x 5½	No
31	Hocking Valley	Ordinary.	⅝ x 5½	No
32	Illinois Central	Ordinary.	9/16 x 5½	Experiment
33	Kansas City Southern	Ordinary.	9/16 x 5½	No
34	Lake Shore & Michigan Southern	Ordinary.	9/16 x 5½	No
35	Lehigh Valley	Chisel point.	9/16 x 5⅜	No
36	Louisiana & Arkansas	Ordinary.	9/16 x 5½	No
37	Louisville & Nashville	Ordinary.	9/16 x 5½	No
38	Michigan Central	Ordinary.	9/16 x 5½	Few exptl.
39	Missouri Pacific	Ordinary.	9/16 x 5½	No
40	Nashville, Chattanooga & St. Louis	Chisel point.	9/16 x 5½	No
41	New York Central	Goldie.	9/16 x ⅝ x 5½	No
42	New York, New Haven & Hartford	Chisel point.	.....	Experiment
43	Norfolk & Western	Chisel point.	9/16 x 5½	No
44	Northern Pacific	Ordinary.	9/16 x 5½	2 miles
45	Pennsylvania	Chisel point.	⅝ x 5½	Experiment
46	Pennsylvania Lines	Ordinary.	⅝ x 5½	25,000
47	Philadelphia & Reading	Ordinary.	⅝ x 5½	No
48	Pittsburg & Lake Erie	Goldie.	⅝ x 5½	Experiment
49	St. Louis & San Francisco	Ordinary.	9/16 x 5½	Experiment
50	St. Louis Southwestern	Ordinary.	9/16 x 5½	No
51	Seaboard Air Line	Ordinary.	9/16 x 5½	No
52	Somerset	Ordinary.	9/16 x 5½	No
53	Southern	Chisel point.	9/16 x 5½	1,000
54	Southern Pacific	Ordinary.	9/16 x 5¾	Few exptl.
55	Toledo, St. Louis & Western	Ordinary.	9/16 x 5½	No
56	Union Pacific	Ordinary.	9/16 x 5½	Few exptl.
57	Virginian	Ordinary.	9/16 x 5½	No
58	Wabash	Ordinary.	9/16 x 5½	No
59	Wisconsin Central	Ordinary.	9/16 x 5½	No

tracks north and south of the curve, respectively, are connected to form the new middle track. Fig. 9 is a view of a stretch of completed three-track section. The through girder span is over the station, the stations being now elevated instead of built upon the ground.

A striking feature of the reconstructed part of the road is the "wave line" grade, the stations being at the summits of 1% grades. This (as explained below) is due to the necessity of opening the right-of-way for public traffic, and putting the stations 14 ft. above the right-of-way. It has been supposed by many that the arrangement was adopted to aid in accelerating and stopping trains, but this (as shown in Mr. Darling's paper) is not the case. Such incidental effect as it may have in this respect applies only to the local trains. As a matter of historical interest it may be noted that in one of the many projects for underground railways in London (England) a wave-line grade was purposely adopted with a view to operating conditions. Each station was at the summit of grades of 1.66%. This project was put forward some 25 years ago, but was never carried out. Its route was approximately that of the present Central London Ry., and it was intended to be operated by storage battery or compressed-air locomotives.

All the improvement work on the South Side Elevated Ry. was done by contract, including not only the foundations and superstructure, but also the track work. On important steam railways it is generally considered best and most economical to have bridge repair and renewal done by company forces. On such lines, however, there is sufficient work to warrant the organization of permanent gangs; it is not probable that it would have been satisfactory or economical for the elevated railway to organize a special force for work lasting only two or three years. It may be noted that at one time a labor strike stopped the work for about eight months, the structure at one point being supported on its temporary blocking for that length of time. All steel construction was done by the American Bridge Co., and the track was laid by the North American Railway Construction Co.

Although the old structure had been built to a standard design, so many little irregularities and variations existed that in connecting the new work to the old, special devices and methods were required for nearly every span. This necessitated furnishing all connections in blank, and drilling them to fit, and seriously complicated the work of the contractor's engineer in charge of erection. As to the track work, so much of this is special work that it could best be handled by expert forces rather than by regular track gangs. The track is notable for the use of screw spikes throughout (Engineering News, June 21, 1906). The rails rest on ⅝-in. flat-bottom steel tie-plates 6 × 8 ins., having shoulders to receive the thrust from the outer edge of the rail base. The spike holes were bored by pneumatic tools, and the spikes screwed in by cross-handled socket wrenches. The floor construction on curves (with tapered ties) was illustrated in our issue of Aug. 18, 1904. In spite of the large number of men employed, their constant proximity to the charged third-rail conductor, and their continual movements across the track to avoid trains, none were killed and only a few slightly injured by shocks. One man was killed, but he was not an employee, and had walked onto the structure by the incline from the car yard. Apparently, the knowledge of the dangerous conditions led each man to keep in mind that he must look out for his own safety.

At two points where the line had curves of 100-ft. radius making a right-angled turn into and out of 40th St., the old double-track curves were replaced by easier curves for the three tracks. The new curves have a radius of 182 ft., compounded to 500 ft. at each end. This work necessitated the movement of parts of the old structure and the construction of extensive new work. This was complicated by the fact that on this street the elevated railway is parallel with the Chicago Junction Ry., whose tracks had to be elevated. This necessitated raising the elevated railway sufficiently to cross the elevated line of the Chicago Junction Ry. In Fig. 6, the railway tracks are at the ground level, and the long through girders marked C are being placed for the realinement of the elevated railway at the crossing. At A and B are the ends of the old part of the structure, the crossing of which has been removed. Fig. 7 is a view of the reconstructed curve, with its skew through girders over the Chicago Junction Ry. Beneath the structure (and parallel with it on 40th St.) may be seen the concrete retaining walls for the track elevation of this latter line.

All steel erection work was done from below by means of shear poles or gin poles. This is shown in Fig. 8, where one of the large girders is being hoisted for the new structure on the curve crossing the Chicago Junction Ry. A derrick car on the structure was used during the last few months of the work. This occupied one track while trains were operated on the other. Even with this machine, however, the gin pole had to be kept in use for much of the work.

TO SPIKES, BALLAST AND CURVE PROTECTION

No.	BALLAST: Kinds Used	BALLAST: Size of Stone Ins.	BALLAST: Depth Under Ties Ins.	GUARD RAILS FOR CURVES: On What Curves	GUARD RAILS FOR CURVES: Flangeway Ins.	Are Tie Rods or Bars Used to Hold Gage on Sharp Curves?	No.
1	Stone, cinders, volcanic cinder, gumbo, slag, cem. gravel, disinteg. granite	.....	6 to 12	None	.....	No	1
2	Stone, slag, cinders, gravel	.....	12	Rarely	.....	No	2
3	Gravel	.....	12	None	.....	No	3
4	Slag, gravel	.....	8 to 12	None	.....	No	4
5	Stone (trap), gravel	¾ to 2	10	20° on side tracks only	2	On side track	5
6	Gravel	.....	12	12°	1¾	No (braces)	6
7	Gravel, cinders, hard sandstone	2	8	.....	.....	.....	7
8	Stone, gravel, cinders, slag	2	10	None	.....	No	8
9	Gravel	.....	8	16° and over	2½	No	9
10	Stone (trap)	2¾	8	Up to 6° / to 10° / over 10°	1⅞ / 2⅛ / 2⅜	No	10
11	Stone, gravel	2 to 4	12	.....	2	No	11
12	Gravel	.....	6 to 18	(No sharp curves)		No	12
13	White limestone, gravel, slag	¾ to 2½	12	19° and over	.....	No	13
14	Limestone, gravel, cinders, bt. clay	2	8	To 5°, 1¾; to 10°, 1⅞; to 15°, 1⅞; to 20°, 2⅛; over 20°, 2⅜ inches		In yards	14
15	Stone, gravel, cinders	Up to 2	6 to 18	10°	1⅞	No	15
16	Gravel mainly	.....	10 to 12	None	.....	Yes	16
17	Limestone, gravel, cinders, bt. clay	2 max.	6 to 10	.....	.....	In yards	17
18	Limestone, gravel	1 to 2	8 at center	A few bridges	.....	No	18
19	Gravel	.....	6	None	.....	.....	19
20	Limestone, gravel, cinders, slag	2½	10	.....	.....	No	20
21	Stone, gravel	½ to 2	12	None	.....	No	21
22	Stone (granite and trap), gravel, cinders	2½	8 to 10	5° and over	.....	No	22
23	Slag, cinders, gravel, earth	.....	10	None	.....	No	23
24	Pit gravel	.....	12 min.	12°	2	No	24
25	Stone (trap and limestone), gravel, cinders	2	12	Various	1⅛	No	25
26	Coraline rock (similar to oolitic limestone)	1½ max.	8	(No curves sharp enough)		No	26
27	Gravel	.....	8	.....	.....	.....	27
28	Granite	2	12	.....	.....	.....	28
29	Gravel	.....	12	16° in yards	2¾	Yes	29
30	Gravel	.....	10	No	.....	On a few mt. grades	30
31	Limestone	¾ to 2½	12	20°	2½	No	31
32	Stone and gravel	¾ to 2	12	(Not on main track)		No	32
33	Gravel (bank and washed), chatts, chert, cinder, stone (limestone, sandstone and trap)	2½	12	25° and over	Variable	No	35
34	Stone, washed gravel (and 8 ins. stone on 12 ins. gravel or slag)	½ to 1½	12	(Not necessary on main track)		No	34
35	Limestone	⅞ to 2½	8	12° on branches	.....	At few points	35
36	Cementing gravel	.....	12	.....	.....	.....	36
37	Stone, slag, gravel	2½	11	(Not required on main track)		.....	37
38	Gravel (6 ins. limestone on 6 ins. gravel)	..... / 1½	12 / 12	35°, yards and industrial tracks	2½, 3	No	38
39	Stone, gravel, cinders, chatts	.....	6 to 12	.....	.....	No	39
40	Stone, gravel	¾ to 2½	8	None	.....	No	40
41	Stone, gravel	¾ to 2	9	None	.....	No	41
42	Stone (trap), gravel	2	8 to 10	(Not required)		No	42
43	Stone (limestone and sandstone), gravel, slag; cinders on sidings and branches	2	10	11° and over	2½	No	43
44	Stone, gravel, sand, cinders, slag	2½ max.	12	18° and over	1¾, 1⅞	Sometimes	44
45	Stone (trap, limestone, hard sandstone & granite)	2 and 2½	12	Where curve and grade require	Close as possible	No	45
46	Stone	¾ to 2	13	(Where necessary for blind driv.)		No	46
47	Stone (trap and limestone)	1 to 2	8	14° and over	2⅜	No	47
48	Limestone	¾ to 2	12	None	.....	No	48
49	Mostly chatts. Also stone, slag, gravel, cinders, earth	2½	10	.....	.....	No	49
50	Stone, gravel	2½	12	10° and over	3 and up	No	50
51	Stone, gravel, slag, sand	2½	6 to 12	None	.....	No	51
52	Gravel	.....	18	.....	.....	.....	52
53	Stone (granite and limestone), gravel	2	8 min.	.....	.....	No	53
54	Stone (basalt and granite), gravel	2	8	10° and over	3	No	54
55	Limestone, gravel, cinders	2	10	over 10°	3¼	No	55
56	Limestone, gravel	¾ to 2½	8	None	.....	No	56
57	Stone	2	6 min.	12° and over	2¼	No	57
58	Gravel, limestone	1½	12	Over 4° on high banks and bridges	8	No	58
59	Gravel	.....	18	Over 6°	1⅞	No	59

During the work it was necessary to operate traffic temporarily over short sections of single track, and the details of the arrangements are described below, in Mr. Darling's paper. In such cases the traffic was handled by flagmen, one man having authority to order the train movements. In spite of the heavy traffic, trains were handled with very little delay. If they became bunched, several trains were allowed to pass in one direction while trains in the opposite direction were held.

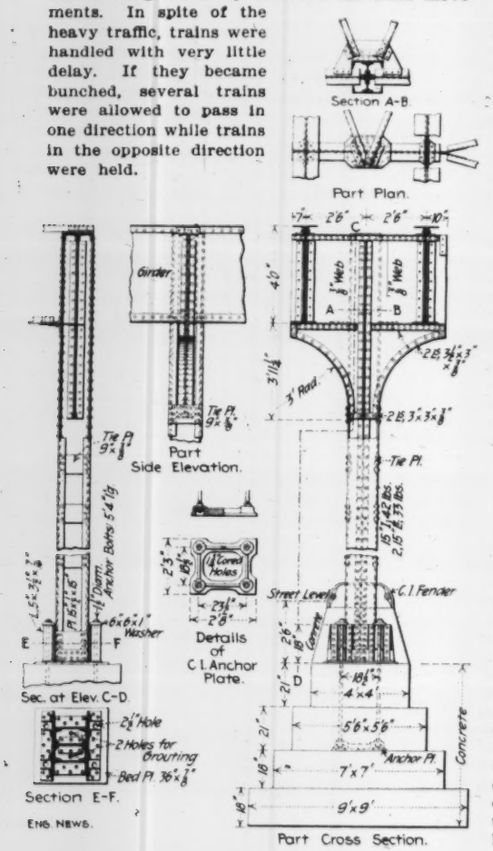


Fig. 1. New Column for the Third-Track Widening of the South Side Elevated Ry., Chicago.

With this general review of the improvement work on the old line, we proceed with Mr. Darling's paper dealing with the various parts and features of the work. This will be published in full in the "Journal" of the Western Society of Engineers (Chicago) and we have been permitted to make use of it in advance of such publication. A map of the line, showing the third track, the extensions, and the connection with the elevated loop is given in Fig. 9.

IMPROVEMENTS AND EXTENSIONS.

The original line of the South Side Elevated Ry., of Chicago, was built in the early 90's as a two-track structure south from Congress St., to 63d St., and eastward in that street to Jackson Park.* At that time the portion of the city which it traversed, especially south of 39th St., was rather thinly inhabited, and the only immediate incentive for building so far south seems to have been the prospective traffic of the World's Fair, in 1893. Owing to the exceptional transportation facilities which this line afforded, the population contiguous to it steadily and constantly increased until it reached a point where, if additional facilities for a more rapid transit to the business center of the city were not provided, this increase would be checked, or would seek some other line of transportation.

To meet the constantly increasing transportation requirements, it was finally decided to add a third track to the existing structure between 12th and 43d Sts., to eliminate existing sharp curvatures at several points, and to make several other important improvements. The additional third track is used for local service, leaving the old east track (now the middle track) for express service. This affords the large patronage originating south of 43d St. a rapid transit to and from the downtown district. It is used for northbound traffic during the rush hours of the morning, and for southbound traffic during the corresponding hours of the evening.

In addition to the work above mentioned, a two-track extension (with a branch line) has been built into and through the thickly settled portion of Englewood. The total length of the Englewood extensions is about 3½ miles. Through arrangements with the Chicago Junction Ry., an extension has been made eastward in 40th St. to the thickly settled portion of Kenwood. This extension, 1¼ miles, is now in service, and is operated on the elevated roadbed of the Chicago Junction Ry. By an arrangement with the same road, a western extension (steel structure) has been built in 40th St., and extends west to the stock yards, with a loop in the yards. A portion of this extension is directly over (and parallel with) the elevated tracks of the Chicago Junction Ry., and here the track girders are carried by cross girders resting upon columns on the concrete retaining walls of the track elevation work.

*Engineering News, 1892, I., 57.

As a necessary part of the extensions and improvements, the old terminal yards at 61st St. and Calumet Ave., originally on wooden trestle, have been entirely rebuilt of steel on concrete foundations. An extensive surface terminal yard has been built south of 63d St., between Calumet and Prairie Aves., approached by an incline. A large increase of power has been installed at the power-house at 39th and State Sts., and interlocking and block signals have been installed.

THIRD-TRACKING AND RECONSTRUCTION BETWEEN 12TH AND 43D STS.

The original two-track structure from 12th St. to 63d St. was built on a private right-of-way, consisting of a 25-ft. strip cut from the rear end of the lots adjoining alleys. In order to widen the structure for the third track without making a further and expensive cut into private property, it became desirable to acquire the use of the adjacent alley for the additional width. A franchise for this use was acquired, and the alley was, in general, used for the addition. But, as a compensation for the privilege thus acquired, the South Side Elevated Ry. was required to pave with asphalt its entire right-of-way and the alley adjacent, from 12th St. to 43d St.; and to throw the whole strip (40 ft. and more in width) open to the public for use as a thoroughfare, the company merely reserving the fee to its own private right-of-way.

This requirement made necessary several other very important and expensive features of the work of improvement: (1) Tearing away all the old stations, which were built on the ground; (2) Building new stations suspended from the structure, with 14-ft. clearance above asphalt grade; and, (3) Raising the existing structure at all stations to a height that would allow of the building of the station underneath, with this required clearance.

The principal engineering features and difficulties were in the work of adding the new third track. All this work had to be carried on in regular progression, and in such a way as not to interfere materially with the comfort and convenience of the traveling public. It was done under a traffic of over 600 trains daily, with intervals of from 1 to 3½ mins.

In the entire third-track work from 12th St. to 43d St., about 660 new concrete foundations were required; 430 of these were for the new track, and 230 were for renewals of old foundations (at station points and elsewhere) where changed conditions due to new construction called for a larger foundation support to carry increased loads. The old foundations were 7 x 7 ft. in the bottom course; the new ones are, in genera... x 9 ft. As con... is ap... structure a total ... lbs. per ... the third ... son of ... structure ... ing and thus affording a much larger bearing surfa... structed the entire weight carried per foun... proximately as follows: for car load, 72,000 ... ture, 41,000 lbs.; foundation, 14,000 lbs. Th... of 127,000 lbs., at an approximate load of 1... sq. ft. on the ground. The 430 foundations ... track were built in the fall of 1904 and th... 1905. The foundations for renewals under th... ture were put in simultaneously with the ... jacking-up of the old structure.

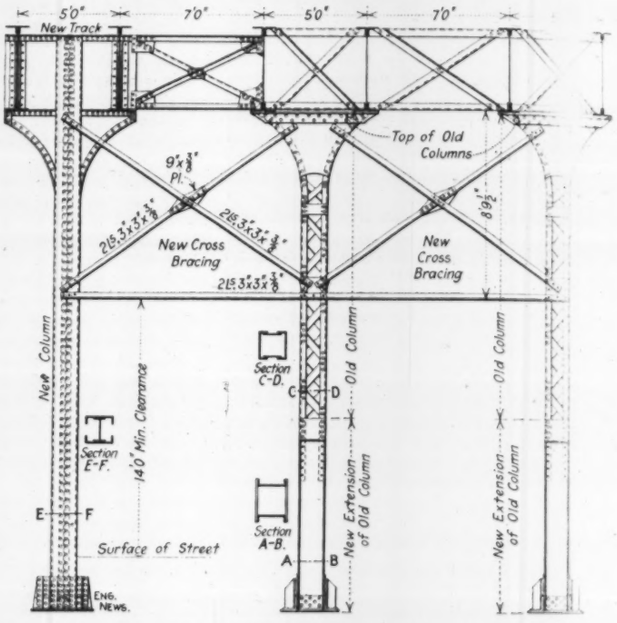


FIG. 2. COLUMN EXTENSION AND NEW TRANSVERSE BRACING OF OLD AND NEW PARTS OF STRUCTURE WHERE THE GRADE IS RAISED.

One of the most extensive elevations of the old structure was from 14th St. over the St. Charles Air Line and on past the 18th St. station, a distance of 2,800 ft. When the St. Charles Air Line was elevated, several years ago, the South Side Elevated Ry. raised its structure to give the necessary clearance. This raise was 13 ft. at the crossing, with approaches of 2.17%. The columns were spliced to give the proper elevation. In the new raise, an approach of 1% was given each way, beginning at about 14th St., meeting the old summit at the crossing of the Air Line, then running off on a 1% grade till the level required for the 18th St. station was reached. It was carried on the level past the station platforms, thence on a 1% grade to the original elevation at a point south of the station. The maximum raise to attain the new elevation was 6.58 ft. (or about 19½ ft. above the original grade). This elevation was commenced in December, 1904, and carried forward continuously to completion. New column extensions were riveted in place as fast as the jacking was completed, the old extensions being removed and used in other places where the additional elevation was such as to allow of their use.

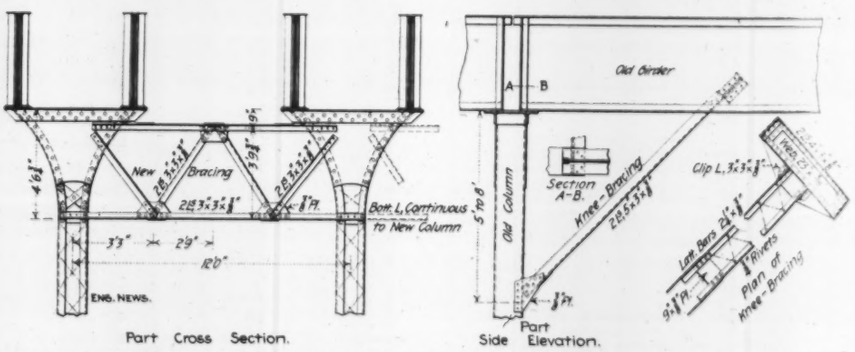


FIG. 3. TRANSVERSE BRACING AND LONGITUDINAL KNEE-BRACING OF OLD STRUCTURE WHERE THE GRADE IS UNCHANGED.

At a point just south of 14th St. (Fig. 4), the old structure crossed from the east to the west side of the alley with a sharp curvature which was to be eased off at a later date in connection with the erection of the third track structure, which changed sides at this point. To provide for the necessary reconstruction here and for the 18th St. station the structure was left on its

blocking at these points. Elsewhere, as fast as the column extensions were riveted in place, the old structure was "handed" and the blocking was removed, leaving the old structure ready to receive the new third track. At the several stations south of 18th St. the structure was raised to attain the required elevation opposite the station platforms, with approaches of 1% each way. The elevation required at the stations ranged from 3½ to 4½ ft., requiring a slope of from 800 to 1,200 ft. to make the elevation.

The work of elevation on 40th St. (which includes the 39th St. and Indiana Ave. stations) was exceptional. Between these two stations the elevated railway crosses the Chicago Junction Ry., which also was elevating its tracks and required a raise of the elevated railway of 8 ft. for clearance. To provide for this, and for the elevation at each of the stations mentioned, required one continuous stretch of elevation beginning at 38th St., attaining the required elevation at the north end of 39th St. station, thence level past the platforms and up over the Chicago Junction Ry. Thence it descends slightly along 40th St. to a level at Indiana Ave. station, and then meeting the old grade of the structure at the south end of the curve at 40th St. and Calumet Ave. The total length of this raise is approximately 3,100 ft. Combined with this elevation, there was also an easement in the alinement of both the east and west right-angle curves at 40th St. This involved a new structure throughout, as well as the necessary reconstruction at each station.

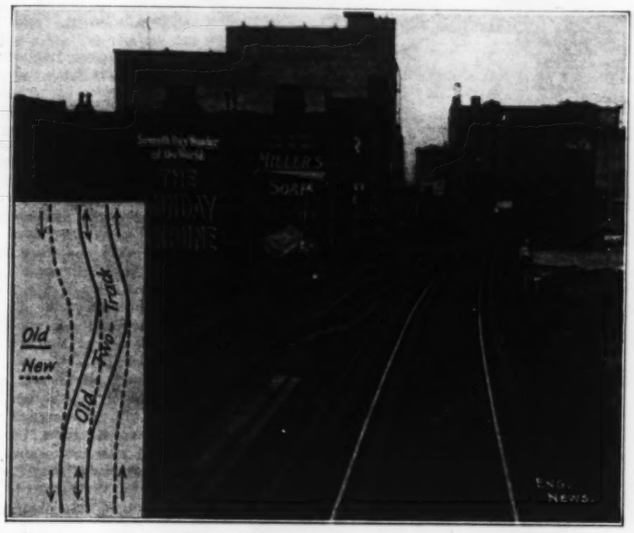


FIG. 4. THIRD-TRACKING ON THE SOUTH SIDE ELEVATED RY, CHICAGO.

(This view is looking north at 14th St.; in the foreground the new third track is on the right; beyond the curve it will be on the left, the old northbound and southbound tracks being connected through the curve to form the middle track.)

The blocking used in raising and supporting the structure is shown in Fig. 10. It was, in general, built up as follows: A practically continuous floor of 4 × 12-in. timbers was carefully leveled on the ground; on this was built a crib work of 12 × 12-in. timbers laid "cob house" fashion, about 6 ft. high, surmounted by a pair of trestle bents of 12 × 12-in. timbers. The bents were of such a height as to reach the track girders, or cross girders, as the case might be. The crib work was built with eight of the 12 × 12-in. timbers projecting; four of these were directly above the other four, forming an intervening space for the 30-ton hydraulic jacks. The working of the jacks in this space divided the crib work by a constantly increasing interval which was kept filled in by 1-in. and 2-in. planks and by wedges until it amounted to 12 ins. The thin pieces were then discarded and an additional 12 × 12-in. piece was inserted. A 12 × 12-in. timber was then placed across the lower projecting ends to raise the jacks. The process was repeated till the proper height was attained.

One set of four jacks was used, raising one track at a time about 3 ins. at each lift for center-column structure, or 2 ins. for cross-girder structure. Each lift of one track was followed by a corresponding lift of the other track. With center-column structure, no difficulty was experienced in handling one side at a time. With cross-girder structure, a 2-in. raise was about the limit, and even with that a few hitch angles were broken.

This work was all done under slow orders for trains, with a flagman on top to stop trains (if necessary) till the amount raised could be caught or filled in with the blocking and the jacks released, as the jacks would not stand the impact of trains. This work was all so carefully and expeditiously handled that trains were rarely held more than a minute or two. No jacking was done during the rush hours of morning or evening, the train interval during the time of work being usually 2½ or 3 minutes.

Where new foundations were to be put in place of the old, the lower course of 12 × 12-in. × 10-ft. timbers was replaced by six 30-ft. timbers 8 × 16 ins., so as to span the required foundation excavation by a safe margin. These timbers were so spread as to give space for removing the old foundation and putting in the new, which work was all done while the structure was carried on this temporary support.

After the structure was carried to its full height, the original foot castings were knocked off by rammers dropped from a height of 3 ft. to 4 ft., and new column extensions of suitable length, built up of 15-in. channels and plates, were riveted in place and anchored. The blocking was then removed.

The additional height of the columns, due to the splicing, required additional strengthening to give the required rigidity to the structure. This was effected by a system of longitudinal knee-braces and cross-bracing at the top, so placed as not to interfere with the required headroom of 14 ft. (Fig. 2).

At each of the old stations there was one bent of the old structure situated within the building. In order to raise the structure and at the same time keep the old station in operation as long as possible, it was necessary to tear out a portion of the building and make temporary changes in the stairways, so as to make the necessary space for blocking at the columns and to make the necessary renewals of foundations. No two stations were alike, and special methods were required in each case. The difficulties encountered were successfully overcome, and the public was, in all cases, suitably provided for during the progress of this feature of the work.

As soon as the raising of the existing structure past a station was completed, the method of procedure was to erect at once a small temporary station across the street from the old station, with landings and stairway connection with the station platforms, usually at the very end of the platforms. Traffic was then diverted to the temporary station, the old station was wrecked, and space was cleared for the erection of the new suspended station.

Meanwhile the third-track structure had been erected on either side of the station and the track laid up to the platform. The span which carries the new station consists of through girders in order to give the necessary headroom for the station (Fig. 5). This required two entirely new bents on new foundations. For this reconstruction, the blocking supporting the existing structure had been left in place. The track stringers on either side of the station span were cut loose and cut off sufficiently to allow for the insertion of the new cross-girders; the new supporting columns were erected from beneath, and the cross-girders were launched endwise into place and riveted to the columns. Track stringers on either side of the reconstructed span were then riveted to the cross-girders, new hitch angles being provided for the purpose. Meanwhile crossovers had been installed between the two old tracks at either end of and beyond the limits of the station platforms.

Up to this time normal movement of trains was not interfered with. At this stage, however, the west track between the two crossovers was abandoned, and all traffic diverted to the east platform. Old track and timber on the abandoned portion was torn out and relaid with new material, the old track girders of the west track at station span were removed, new through girders were erected and riveted, and new track was laid over the bridge. Double-track service was now temporarily resumed, during which crossovers were interchanged preparatory to single-track movement on the other track. This process required usually three or four days. Single-track service was installed on the west track; the old east track was torn up and relaid with new material, and the remaining through girders of the station span were erected. The east platform was then jacked over 12 ft. eastward onto cantilever brackets extending from the new third track columns. The middle and east tracks were laid through the bridge to a connection, and the temporary stairway leading up to the east platform was adjusted to the connection. Double-track service was then permanently installed on the two outer tracks, leaving the middle track ready for future use in express service.

The suspended steel structure for the support of the new station was next erected. The new station, with landings and stairways, was built entirely without hindrance to traffic, the temporary station being maintained till the permanent station was ready for use. The occupancy of the permanent station and the demolition of the temporary one marked the completion of the work. The erection of the steel work at a station, and the construction of the station ready for occupancy, usually required from 60 to 90 days.

As all the work was carried out under traffic, it involved many trying and difficult problems both of design and execution. And its essential features were so closely related and inter-dependent that no single phase of the work could be treated independently. Everything had to be carried out (in the field as in its design) as a part of a complicated whole. In all the work the original plans and designs were not deviated from in any essential detail, and during the whole course of the work there was no accident and no serious inconvenience to the traveling public.

FIG. 5. PART OF COMPLETED THIRD-TRACK WORK AND STATION.

The question was often asked whether the wave-line grade adopted was to secure an advantage in the handling of trains. I would state that the grades were established solely to secure the necessary headroom under-

neath the stations. Whatever advantage may have accrued (and this would be confined exclusively to the movement of local trains) is merely incidental.

RECONSTRUCTION ON 40TH ST.

Special mention has been made of the reconstruction along 40th St., as involving many difficult features not encountered elsewhere on the work. The old two-track structure at the east and west curves was built with radii of 100 ft., necessitating very slow movement of trains. An elimination of this undesirable feature was important, and a part of the work of reconstruction of this portion of the line was made to comprise an entire reconstruction of these two curves. Radii of 182 ft. are used in the central portion of each, compounding with curves of 500 ft. radius at the ends.

In order to secure the required curvature at the west curve, local conditions made it necessary to cut across the old structure in 40th St., and to end the new construction at the east end of the new curve about 6 ft. south of the old alinement in 40th St. It was thus necessary to jack the old structure onto new foundations to meet the new structure, and to introduce curvature of easy radius at the pivotal point of this movement just west of Michigan Ave. Fig. 11 shows the trestle-bent blocking supported by sills resting on rollers on top of the crib blocking, to allow of shifting the old structure laterally.

The course of procedure for the entire work of reconstruction of this portion of the line, beginning at 38th St. and ending at the south end of the east curve in the alley between Prairie and Calumet Aves., was essentially as follows:

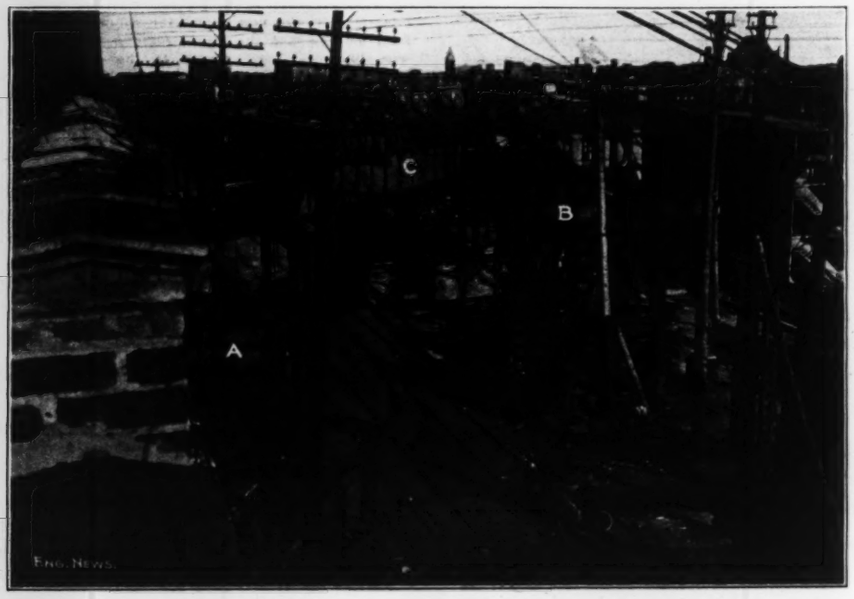


FIG. 6. RECONSTRUCTION AND REALINEMENT OF RIGHT-ANGLE CURVE TURNING INTO 40TH ST. (LOOKING EAST ALONG 40TH ST. AND THE CHICAGO JUNCTION RY.)

(The old sharp curve between A and B has been torn out; the large through girders at C are for the new three-track curve.)

During February, 1905, the old two-track structure was jacked-up to its new elevation (6 ft. above the old grade) through 39th St. station, with its permanent run-off north to 38th St. and a temporary run-off south toward 40th St. Column extensions north of the station were riveted in place. The structure was landed and blocking removed, except that at the station the structure was left on its blocking to await future reconstruction. The structure under the temporary run-off was also left on its blocking, to be used in a further raise at a later stage of the work. While this work was going on, new foundations were being put in for the change of line at the east curve. The existing structure at the east curve was now jacked-up to the grade established for the reconstructed line. The elevation began about 300 ft. south of the south end of the old curve, extending (at the established grade) past Indiana Ave. station and ending, at this stage, in a temporary incline west of the station. The maximum raise (opposite the station platforms) was 4.7 ft.

Following the jacking, column extensions were riveted to the columns that were to remain in t[he] that portion of the structure that was to b[e] new structure was left on its blocking. [N]ew third-track structure, on the east si[de] from 43d St. to the south end of the ne[w] erected. Next all that portion of the ne[w] that could be put up without interference [with] structure and with the operation of traine[s] on its new foundations, and at the same ti[me] being laid on the new third-track struct[ure] 43d St. and the south end of the new curv[e] southbound track from the east end of the [old] Indiana Ave. station over the new structu[re] laid ready for a connection.

Up to this point, traffic on the two old [tracks] not been disturbed, but it was now necessa[ry] traffic, and the series of arrangements is [shown] plans A to F, Fig. 12. In the first place, [a] service was installed over the old northboun[d] tween crossover No. 4 (just east of the [station] crossover No. 8 just south of bent No. 537, [where] and old construction were to be joined. Whi[le] ran over the one track between these crosso[vers] A) the old southbound track and structure [around] curve was torn out and the new southboun[d] was connected with old southbound at ben[t] The new southbound track was laid to a conn[ection] the old one at that point, and crossover [No.] laid (Plan B).

Two-track service was now resumed around the curve, using the old northbound track and the new southbound track, with crossover No. 5, as shown. During this movement of trains, crossovers No. 4 and No. 8 (in Plan A) were interchanged as shown in Plan C. Single-track movement over the new southbound track around the curve was installed, leaving free the old track and structure between these crossovers.

The balance of the old structure around the curve was now torn out and the new structure for the middle and northbound tracks was erected. The track was laid around the curve, except for a gap between S and T (Plan C), which could not be completed till traffic was diverted from that point. Hence a crossover No. 10, west of the station, was now laid; crossover No. 4 was abandoned, and the single-track movement was extended westward through the station on the southbound track, using crossovers Nos. 10, 5 and 8 (Plan D). During this movement, structure and track were completed between S and T (Plan C), and the through girders of the northbound track at the station span were erected. The old track through the station was torn up and new track laid.

Continuous double-track service was now again resumed, as shown in Plan E, the middle and northbound tracks to 43d St. being used. During this train movement, the right-hand crossover west of the station was changed to left-hand, and the new crossover east of the station (connecting the middle and new southbound tracks) was taken out. The situation was then as shown in Plan F. Single-track movement on the northbound track through the station was now installed over these crossovers. During this movement, the structure for the new southbound track was erected past the station, the south platform was jacked-over to its new position (Plan F), the remaining through girders at the station span were erected, and the new south track was laid through the station.

While the above mentioned work was in progress, a temporary station had been erected at Prairie Ave., and the old station wrecked. On the site thus cleared, the new station was erected on the steel work suspended from

FIG. 7. VIEW OF RECONSTRUCTED THREE-TRACK CURVE AT WEST END OF LINE ON 40TH ST. (LOOKING SOUTHEAST.)

(The stub track is the coal track at the back of the power station. The concrete retaining walls are for the track elevation of the Chicago Junction Ry. in 40th St.)

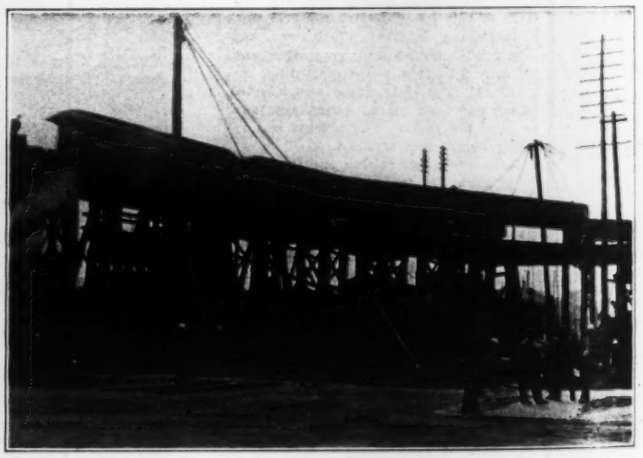


FIG. 8. HANDLING LARGE GIRDERS BY SHEAR POLES (WEST CURVE AT 40TH ST.)

the structure at the through span. At the same time, the jacking up of the old structure from Indiana Ave. to 39th St. had been carried steadily forward to completion. All structural changes and additions from Indiana Ave. station southward being now complete, final two-track service on the outer tracks from a point just west of Indiana Ave. to 43d St. was now installed.

The situation at the west curve at this stage was as shown in Plan G (Fig. 12), the new track and structure being completed to the point mentioned, with the crossover used in this service in position. By July, 1905, the erection of the new third track structure had been carried westward to bent No. 499 (shown on Plan H); also the new middle track structure between bents Nos 499 and 502 was erected. A temporary trestle outside of the existing structure from bent No. 496 to No. 499 was erected to connect the old and new southbound tracks for temporary purposes of construction. Meanwhile, tracklaying had been kept close up with the erection, and by July 23, track was all laid over the new southbound track and the temporary trestle ready for a connection at bent No. 496. To make this connection and at the same time to disconnect crossover Q P (Plan G), Sunday was chosen, as comparatively few trains were run. In the forenoon, track connection was made at the point mentioned and crossover Q P was removed from the southbound track, all southbound trains being diverted to the northbound track at crossover A (Plan H) and switched back to the southbound track at 43d St. On the completion of this work, two-track service was immediately resumed, southbound trains being run over the temporary trestle and new southbound track. The switches shown at R S and at W were for future single-track movements.

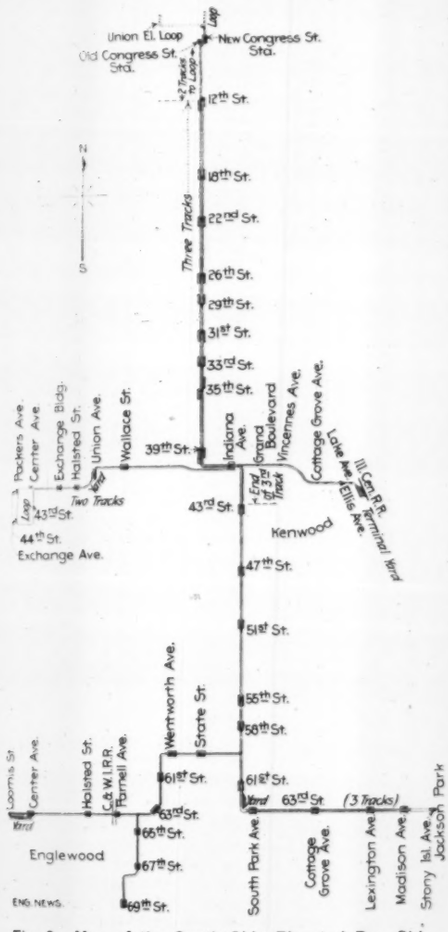


Fig. 9. Map of the South Side Elevated Ry., Chicago (Including the Recent Extensions).

The middle track being clear, a portion of it west of T, near bent No. 502, was swung over and connected with switch R S. Single-track movement around the west curve was installed, northbound trains passing via crossover C T S R, the temporary trestle, and crossover B to their proper platform at 39th St. station (Plan H). Southbound trains continued by the temporary trestle and new southbound track to Indiana Ave. station and southward. This left all the east portion of the old structure of the curve clear for tearing out and rebuilding.

During this single-track movement the following work was done: Completed erection of new east track structure from curve at 40th St. to south end of station platform at 39th St., as shown on Plan H, and erected through girders for new north bound track over Chicago Junction Ry. at 40th St. Meanwhile all free old structure between bents Nos. 499 and 502 was torn down and new structure was erected in its place. Right-hand crossover Q P was changed to left-hand Q P on the same location. New east track between 39th St. and bent No. 499, including that portion through the east girder span, together with all other track that it was possible to lay was laid. In order to get at the balance of the old curve and to erect the new, it was necessary to abandon the crossover R S T (Plan H). This was effected by extending the single-track service to Q' P' just east of bent No. 507. Then R S T was taken out, and turnout W, just west of bent No. 502, was laid to a connection with the new northbound or east track, just south of the through girder span. A switch was inserted in the line for the future or completed northbound track.

The work had now advanced to a point where another diversion of traffic was necessary in order to vacate the balance of the old structure at the curve. On Aug. 11, 1905, single-track movement was installed as shown in Plan I. Southbound trains came onto the single track at A and C, and northbound by I K P' Q'. This movement left the old two-track structure between bents Nos. 502 and 507 out of service and ready to be jacked-over to its new position parallel with the new third track, and to a connection with the new three-track structure west of bent No. 502. For this purpose the structure had been left on its standard blocking on rollers provided for the purpose (Fig. 11). The balance of the old curve structure was torn out, and the remaining through girders over the Chicago Junction Ry. were erected, as well as the remainder of the structure south of the through girder span.

The new northbound track was now laid westward on its permanent location to a connection with its corresponding track at bent No. 499, at the switch previously mentioned (Plan J). On the completion of this connection single-track service was shortened up to this point from the east, greatly facilitating the handling of trains. A left-hand crossover was now installed between the two old tracks just north of 39th St. station, for use during the reconstruction at that station. Single-track movement over east track at the station was now installed, extending from R to P in Plan K. Southbound trains came on at S R, and re-entered the southbound track at P. The old west track was now torn up past the station platforms; new through girders for the west track at the station span were erected, and the new southbound track south from the station was laid.

Double-track service through the station was now resumed, the single-track service being now limited to C O P, in Plan L. During this movement, the crossover north of the station was changed from left to right, whereupon single-track movement was diverted to the southbound track at the station and combined with the continued single-track movement across 40th St. The single-track movement now extended from V over crossovers B C and N O to P, in Plan M. During this movement, the new third-track structure was erected northward past the station; through girders were erected for the middle and east tracks at the station span; and the east platform was jacked-over to its new position for the third track.

Meanwhile the southbound track had been laid to a connection with its corresponding track on 40th St., and double-track service was immediately installed south of 39th St. on the two outer tracks (as shown in Plan N), thus shortening the single-track service to the space between V and B at the station platform. The new northbound track was laid past the station to a connection with the corresponding track that had already been laid between 39th and 35th St. stations. Double-track service was installed, thus making the operation of the third track continuous from 43d St. to 35th St., and leaving the middle track between these points free for future express service.

The entire work of adding the third track, reconstructing the curves, raising the old structure, etc., from 38th to 43d Sts., covered a period of about eight months, from Feb. 1 to Sept. 27, 1905.

FIG. 10. ARRANGEMENT OF BLOCKING FOR RAISING THE OLD STRUCTURE.

CONCRETE PILE FOUNDATIONS TO A HEAVY REINFORCED-CONCRETE WAREHOUSE.

By CHARLES R. COATS,* C. E.

In the construction of an exceptionally heavy reinforced-concrete warehouse for the Belknap Hardware and Manufacturing Co. at Louisville, Ky., the problem of proper footings was greatly complicated by the uncertain nature of the ground, which was in one part an old fill and in the remainder a former creek bottom, the whole dotted with a number of old cisterns. After considerable study the engineers decided to found the footings on concrete piles, a construction rather novel in so heavy a piece of work, but one which has proved quite successful.

The building is to be occupied by a hardware company storing and using very heavy goods, so that large live loads were prescribed, varying from 400 lbs. per sq. ft. for the two lowest to 300 lbs. per sq. ft. for the upper floors. These loads required such large members that in the 34,125 sq. ft. plan and 9 stories height, the total dead load was 26,100 tons and the total live load 50,250 tons. As there were 157 footings in the entire system, these heavy loads necessitated a load of 485 tons per footing under a full live load.

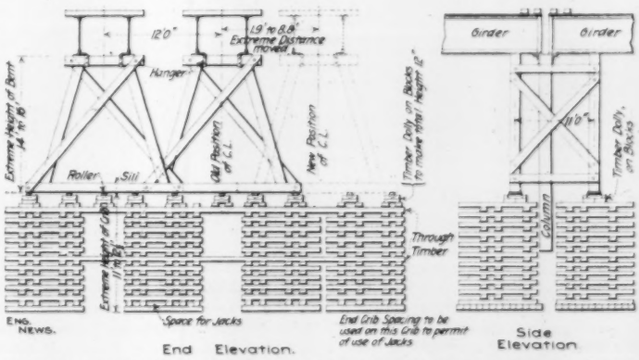


FIG. 11. BLOCKING WITH ROLLERS UNDER TRESTLE BENTS FOR MOVING THE OLD STRUCTURE LATERALLY.

In preparing plans for this heavy substructure, spread and mattress foundations, creosoted timber, and the various types of concrete piling were considered, but concrete piles were decided

*R. R. No. 10, Newburgh Road, Louisville, Ky.

upon as offering the most reliable type of foundation, because of the certainty of the integrity of the finished pile, the greater bearing strength and the probable long life in an alternately wet and dry ground. In a soil which is alternately wet and dry, wood piling, even when creosoted, is a constant menace to the superstructure which it supports. Among other contingencies are the possibilities of imperfect saturation during creosoting and subsequent disintegration of the piles by dry rot, and other causes, and impairment of their integrity by brooming, splitting, and telescoping during driving. Other difficulties attendant upon the use of wood piling in this instance were the excessive number of wood piles which would have been required, all 1,341 piles were driven, ranging in depth from 16 to 40 ft., averaging 22.7 ft. Two drivers were employed, one using a 20-ft. core, the other a 40-ft.

During the process of filling the shells, a rod of 3 × 1-in. section extending the entire length of the shell was kept constantly moving within it with an up-and-down churning movement. As each wheelbarrow deposited its contents, careful watch was kept to see that the shell did not collapse from soil pressure. The concrete used was a 1:3:6 gravel mixture.

An investigation of the erratic behavior of the shells of a number of test piles driven at different points showed the cause to be several old brick-walled cisterns, lying in the path of the

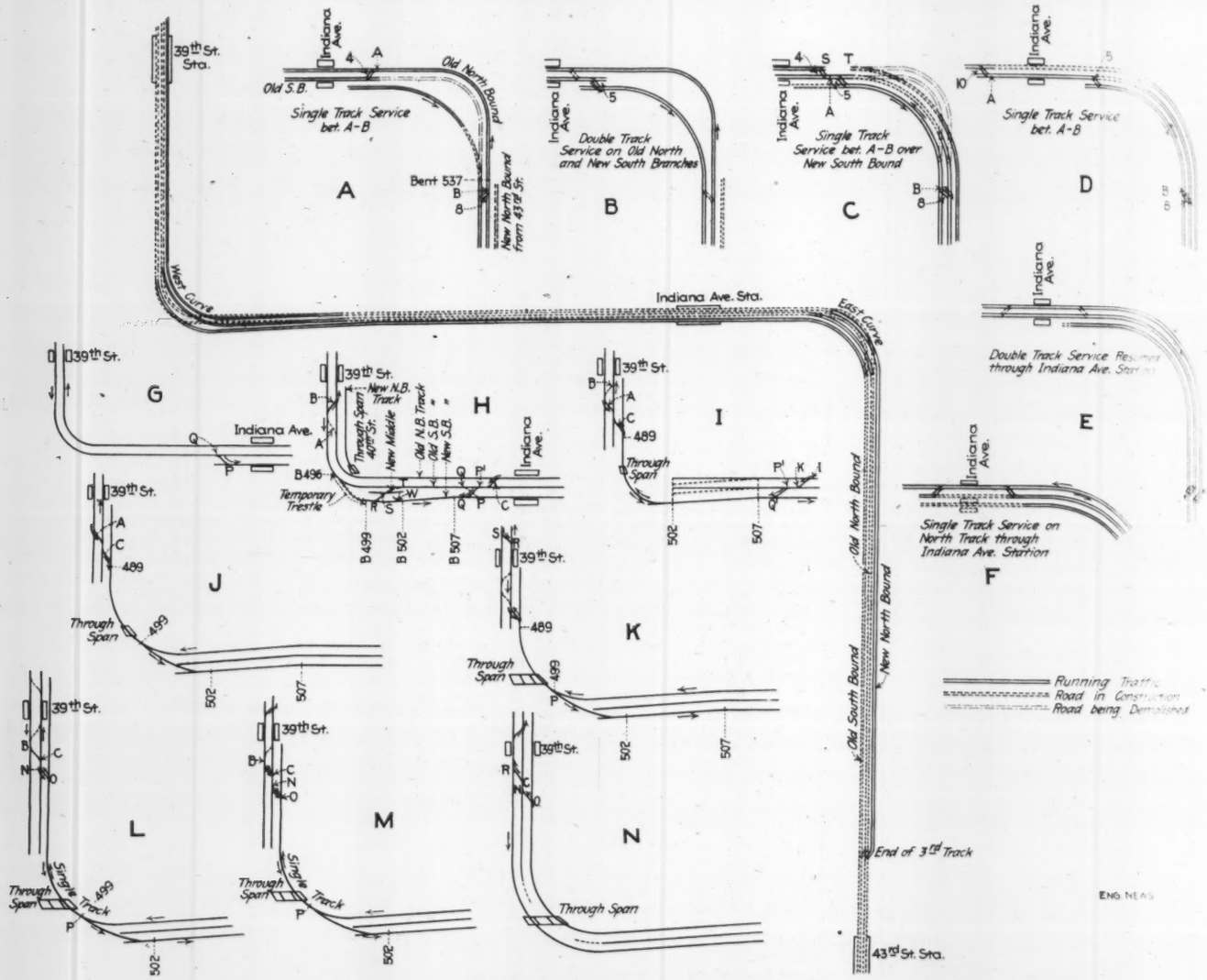


FIG. 12. PLANS SHOWING ARRANGEMENTS OF TRACKS AND CONNECTIONS FOR HANDLING TRAFFIC DURING CHANGES AT EAST AND WEST CURVES ON 40TH ST.; SOUTH SIDE ELEVATED RY.
(Plans A to F for East Curve; Plans G to N for West Curve.)

owing to the slight bearing value of each; the necessity of obtaining timber of varying lengths, the uncertainty of transportation and the waste of material at the point of cut-off. The demand for varying lengths of piling was due to the fact that in the creek bottom, the natural soil was but a few feet below the surface. For certain structural reasons, the engineers selected the well-known Raymond pile, described in Engineering News, March 10, 1904, p. 234. The main detail of this pile is a preliminary tapered steel shell which is driven in place and afterward filled with reinforced concrete.

The piles were driven in groups under each footing, the smallest containing 5 piles, and the largest 21, and averaging 9, are laid out as nearly as possible on a basis of 3 ft. c. to c. In shells, and filled with lime putty and a debris of rotten wood, brickbats, and cinders. Some of the cisterns extended to a depth of 60 ft. The cisterns were cleaned out, their walls and bottoms removed, and were filled with loam sand thoroughly rammed and flooded. After this, the shells were placed without any further difficulty. The largest of the cisterns is directly under one of the heaviest loaded columns in the building.

Experiments showed that a safe working load was about 40 tons per pile and that this bearing could be reached with a $\frac{5}{8}$-in. penetration under the last six blows of a No. 2 Vulcan steam hammer. To ensure an economical foundation, the whole of the dead load and 25% of the live load was used as a basis of calculation. On account of the small proportion of live lo[illegible]sed, it was deemed advisable to reduce the [illegible]ring value of each pile to 30 tons. As the [illegible] live load equaled about twice the total d[illegible]load, this reduction in safe bearing power of [illegible] pile from 40 tons to 30 tons, under a loading [illegible]total dead + ¼ live, is equivalent to prescrib[illegible]a load of total dead + ½ live, with an assume[illegible]e bearing power of 40 tons per pile.

The piles were capped with reinf[illegible]d concrete in the usual manner with the exce[illegible]n of those on the north end, which acted as [illegible]tilevers in order to avoid the foundations of [illegible] adjoining warehouse, owned and operated b[illegible]e owners of the new structure. These found[illegible]ns are 20 ft. below the basement floor and pr[illegible] approxi-mately 8 ft. south of the north line of the new building. It was necessary, therefore, that piles be driven south of this point and cantilevered over to the old structure. Upon these cantilevers is built a railroad trestle, with a capacity of five cars, which is not connected with the adjoining warehouse. No part of the superstructure is permitted to rest upon or adjoin any part of the old building. The floors of each building are on the same level and the walls on the various floors are pierced by elevator and passage doors for convenience in handling freight.

On the east side of the building is another system of cantilevers, built to widen the roadway. Eight stories of the building are carried in this manner. These cantilevers are 12 ft. in length and upon them rest 13-in. curtain walls.

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As the result of much public discussion concerning the safety of the Blackwell's Island Cantilever Bridge over the East River at New York City, an expert examination of the structure is to be made. The bridge was designed about the same time as the Quebec Bridge, and its compression chords are not only of the same general type as those of the latter, but in the maximum case have considerably larger areas of cross-section.

Public attention has been drawn to the fact that there is no better guarantee for the security of these chords than there was for the safety of the Quebec Bridge chords, and as the maximum unit stresses adopted by the designers are the same for the two bridges, the public concern for the safety of the bridge is natural.

However, the Blackwell's Island Bridge is designed for a very high live-load, and in this respect has a larger margin of safety over any loading that can come on the bridge for some years in the future than the ill-fated Quebec Bridge had. While a unit-stress of 24,000 lbs. per sq. in. is used, this occurs only under "congested" loading, i. e., that load which would exist if the whole bridge were completely covered with cars, wagons and pedestrians on all the roadways. Such loading would probably never occur in the life of the bridge. The "working" live-load is just half this amount, and the stresses for that case are much below 24,000 lbs. per sq. in.

Furthermore, the compression chords have much stronger lattice-bars than those of the Quebec Bridge chords, though the riveting of these bars is no stronger (see Table I in App. 17 of Report of Quebec Bridge Commission, Eng. News, April 30, 1908, p. 484).

The city's Department of Bridges, which designed the structure, has not thought it necessary to make tests of the strength of the chords, partly in the belief that tests of small-scale models are of little value, and of course no testing-machine exists which could test the full-size chords.

Now, after a persistent newspaper campaign, the Department has decided to secure an expert report on the structure, and has engaged Prof. Wm. H. Burr to investigate the bridge and report on it. At the same time the Comptroller of the city has independently engaged the firm of Boller & Hodge to report on the strength and safety of the bridge. In the course of a few months, therefore, two reports on the bridge will be produced, and there will be a more definite basis for deciding whether or not tests should be made to determine the safety of the compression chords.

How to do away with the morning and evening crowding on the Brooklyn Bridge was for twenty years an ever-present problem. Its place is now taken by the problem of how to reduce the crush in the New York subway. Doubtless this newer difficulty will remain alive an equal length of time. Excellent suggestions for its solution are made in the report of Mr. B. J. Arnold abstracted in another column, and if they are carried out, as some of them may be, they promise to increase the capacity of the subway in a very gratifying way. But that will be only a partial help. The city has outgrown the single subway line just as it soon outgrew the Brooklyn Bridge. And, as the bridge difficulty was not relieved until a parallel line, the Battery tunnel of the subway, took away the peak of the bridge traffic, so the subway difficulty will probably remain with us until a parallel line is built. At present, unfortunately, a shameful condition of poverty keeps the city from constructing such a parallel line, already planned, and the prospects are not made clearer by bickerings between city officials and others. But in time, no doubt—for while there's life there's hope—in time a second north and south subway will be built in New York, and then the crush difficulty will for a short time be removed.

The importance of Mr. Arnold's studies lies not so much in their application to the New York subway as in their application to rapid-transit lines generally. In this relation they touch, or in the future will touch, every large city. Rapid-transit lines may look forward to a great development. The early promise of the electric trolley car, that it would carry the people between home and work-room quickly, has to a great extent proved illusory; the multiplication of intersecting lines and the increase of congestion in business districts has made the surface car movement increasingly slow and uncomfortable. Rapid-transit lines are the logical solution, and they will be built in answer to the evident need. Fifteen years ago this country knew practically none but the Chicago and the New York elevated railways. At the present moment rapid-transit lines are being discussed in three or four cities that added together have not the population of either the New York or the Chicago of the Columbian year.

Future rapid-transit lines must profit by what their predecessors learned. The chief lesson of the past is that CAPACITY is the important thing. Everything must be done to make one dollar of first cost produce the largest possible hourly passenger-carrying capacity. The utterly unfounded but still prevalent notion that capacity can be increased by increasing the speed of running must not be allowed to befog the mind. As a matter of fact, greater speed means actually *less capacity*, as is clearly shown by the diagrams reproduced in our abstract of Mr. Arnold's report. The capacity is inherent in the system itself, and in its method of operation. Thus, in the New York subway we find that the line itself is so built and equipped that only half as many passengers per hour can be carried as could be carried on the same number of tracks and with the same number of cars per train. The stations, and the remarkable cross-over at 96th St. set tight up against a station—the very worst place—are responsible for this. The track between stations is only half utilized, has only 50% efficiency, during the rush hours. And all this because the importance of maximum capacity was not fully appreciated, and its factors not well known, at the time the subway was designed. Yet, a study of the operating difficulties of the Manhattan elevated lines in the same city would have revealed the crucial features. So should the future rapid-transit lines take advantage of the experiences of the New York subway.

As concerns the factors studied by Mr. Arnold, we need only refer to his report. But, in addition, we would call attention to a rather important detail not clearly discussed in this investigation. The matter in question is the extent to which traffic congestion reacts on the railway itself.

In the period just before the subway was opened the Manhattan Elevated Ry. in New York City was afflicted with the worst kind of congestion. As the rush hour crowd came on, the exit and entrance of passengers through the densely packed aisles of the cars lengthened the station stops (which normally ranged from 10 to 30 secs.) to 60 secs., 80 secs., and often even 120 secs. This at once reduced the train capacity of the line from a point above 60 or 80 trains per hour to less than 30, and the trains were strung along the track in a nearly continuous row. The passenger capacity of the line was cut in half in the hour of greatest demand. This is exactly what occurs to-day in the subway, though not in so pronounced a degree. The Manhattan was specially hampered by one or two bad features; narrow aisles, narrow exit-passages, and inward-opening gates, all of which intensified the delaying effect of car crowding. In the subway, with wide aisles, wide doors and sliding gates, the congestion effect is less abrupt, and at the same time the *normal* capacity in trains per hour is smaller than on the Manhattan because of higher train speed, block signals and longer runs between stations. While these conditions make the effect less pronounced, yet the general phenomenon is the same, viz., the congestion reacts on the system and reduces its capacity at the very time when the capacity is most needed.

What this means is simply that when the car loading is carried beyond a certain point the system is loaded beyond its powers. Up to this point the crowding, of moderate degree, represents a proper loading—from the standpoint of capacity; beyond this point the loading is truly excessive. The point in question gives maximum capacity, measured in terms of passengers actually carried; a greater car loading carries actually fewer passengers per hour because the number of trains which reach any given station during a unit of time is reduced more rapidly than the loading per car is increased.

The question is how to develop this maximum capacity. It can be done by using cars and stations of such type as will permit perfectly free interchange of passengers at even the highest degree of congestion; Mr. Arnold's recommendations for multi-door cars, separated station-platforms, etc., aim at this result. It can be done, in fact a higher maximum can be reached, by providing such an excess of station trackage that even the longest stop, due to the most crowded train, cannot operate to delay succeeding trains; but then, of course, the order of departure of trains must be freely variable, i. e., the tracks must not be gauntletted between stations. Mr. Arnold's designs for "reservoir" stations have this result in view. Finally, it can be done independently of special equipment by rigidly limiting the car loading to the point known to give maximum line-capacity. For example, if with a given type of car it is determined that anything over 100 passengers per car reduces the line capacity, then the cars should be strictly kept down to say 90 or 95 passengers as a maximum. It is not sufficient to attempt to limit the length of stop, for this may still permit attaining a car loading so high that at some station the mere unloading of passengers will hold the train beyond the limiting time and thereby delay all trains on the system for the length of that excess time.

Multi-door cars, separated platforms, "reservoir" stations and the like are very important features. Yet they will not be provided in *all* rapid-transit lines of the future; elevated railways, for example, can hardly obtain width enough at stations for the extra station tracks and platforms. In all such cases, therefore, the problem of maintaining the capacity must rest on rigidly systematized and carefully studied methods of operation. The saving of seconds, not by a special train with a special crew, but by every train and at every station, must be made the objective of a steady campaign.

The opposition to the bill for creating the Appalachian and White Mountain forest reservations prevented any action upon it at the session of Congress just closed.

Meanwhile the clearing of the steep mountain slopes in the South and in New Hampshire goes rapidly on. In the latter state it is estimated that five years more will see the last of the timber on the steep mountain slopes. If the Government is to act at all, it should act quickly.

Perhaps nothing save high-minded and patriotic zeal for the public welfare is the cause of the adamantine opposition to the Appalachian forests bill; but it is said to be the fact that some very extensive lumber operations in the South are conducted on lands which the lumber companies neither own nor lease. Business of this sort would naturally be interfered with, if the Federal Government were to acquire the lands, although the rightful owners of the property would be benefited. If it is business of this sort which stands in the way of a measure of public necessity, it is time that light was let in.

The fire danger of the ordinary type of wooden pier in use in the harbor of New York and most other American cities on the seaboard was well illustrated recently in New York City when the pier of the Joy line of steamers on the East River caught fire and could not be extinguished for days. The pier is built on piles on which rests a heavy wooden floor, creosoted to preserve it from decay. The fire became established underneath this floor and there was no means of extinguishing it. Firemen in row boats attempted to carry hose beneath the pier to attack the fire, but the clouds of noxious smoke from the creosoted wood drove them back. Chopping holes in the wooden floor enabled the hose to reach and extinguish only a small area of fire.

The object lesson as to a reform in pier construction which shall employ only incombustible materials is about as notable as the one which was given eight years ago, when the Hoboken piers of the German steamship lines were destroyed with heavy loss of life.

The bill to make the Inland Waterways Commission an official body and to appropriate $20,000 for its expenses passed the House with only two votes against it, but failed of passage in the Senate. The great importance of the work the Inland Waterways Commission has to do is well known to engineers, and is doubtless well known to the Senate. There is no doubt at all that the Commission should be made an official body with power to act and funds to carry on work. Why did the Senators refuse to perpetuate the Commission? Not from motives of economy, surely. The Commission could save many times twenty thousand dollars every year to the country by merely substituting intelligent planning in place of haphazard work in carrying on river and harbor improvement. Is it possible that the Senators prefer the present lack of system, with its barter and sale, its log rolling and its many opportunities for political manipulation?

In an editorial note in our issue of May 14, we called attention to the defective specifications for sewage disposal plants at army posts. It was not stated in the note what Government department was responsible for these specifications; but a correspondent calls attention to the fact that this work, like all construction work at army posts, is done under direction of the Quartermaster's Department of the Army. The Corps of Engineers of the Army has nothing to do with such works, its responsibilities for army post construction being confined to sea coast and other fortification work.

These facts were known to us and the responsibility of the Quartermaster's Department was not specifically stated because it was desired to aim the criticism at the fault itself rather than the department responsible. The idea that blame might be placed in the wrong quarter by readers unfamiliar with the facts had not occurred to us until pointed out by our correspondent.

A REVIEW OF STANDARDS OF AMERICAN RAILWAY TRACK CONSTRUCTION.

Investigations as to the standard track construction of American railways were made by us in 1896 and in 1900, and the results were presented at considerable length in our issues of June 25, 1896, and Aug. 30, 1900. During the past few years there has been a tendency to strengthen the track on main lines in order to meet conditions of increased engine loads and increased traffic. A similar investigation, therefore, was again made in 1907-08, to ascertain present standards of main-line track construction. The results of the latest inquiry are tabulated elsewhere. The railways included in the tables represent those of the smaller class as well as the more important lines and railway systems. They have an aggregate length of 153,800 miles, of which 15,100 miles are in Canada (on two railways). The total railway system of the United States is approximately 225,000 miles, in round numbers, and about 66% of this grand total (nearly 140,000 miles) is represented by the railways for which information is given.

The information (which has been obtained through the courtesy of the engineers of the various companies) is very complete, but it must be remembered that the extent to which the standards are in actual use is an unknown and extremely variable quantity, especially as the combination of the standards of all component parts in one piece of track on any road is comparatively rare. It will be of interest, however, to review the features of present standards in track construction as indicated by these tables.

The mileage of the railways listed is given as a general indication of the importance of the several lines, but the figures have little bearing upon track conditions. Thus a railway having several hundreds (or perhaps thousands) of miles of line may, and generally will, include various kinds of track and traffic conditions on different parts of its system. It may also have but a very small percentage of its mileage laid with its "standard" track construction. On the other hand, the shorter railways include two classes of lines of very opposite character: First, Those carrying continuously an extremely heavy traffic; that is, heavy as to both density and loads. Such lines, especially for coal and ore traffic, may be laid mainly with a heavy standard track. Second, Those railways which serve local districts and whose traffic is light both in density and loads. These seldom need heavy track. A discouraging feature as to the larger systems above mentioned, with varying qualities of track construction, is that their heavy freight trains and their fast and heavy passenger trains are likely to run over track representing various degrees of quality of construction. The quality of maintenance and condition of track is also likely to vary in equal ratio. Thus the "maximum" freight train and the much-advertised fast passenger train may for considerable parts of their journeys run upon track which gives but a low factor of safety, and which is itself subject to excessive injury by the character of the service which it has to carry.

As to weight of rail, there has been a very general raise in the "standard," which is, of course, the maximum. Of 40 railways, 18 report the same standards as in 1900, 5 report an increase of 5 lbs. in weight, 9 report 10 lbs., 2 report 15 lbs., and 4 report 20 lbs. Two lines report a reduction (90-lb. instead of 100-lb. rails); this probably indicates that the so-called standard 100-lb. rail was actually introduced to a very small extent, if at all. Some railways reporting two or more standards have dropped the lower figure of former years and have added a higher one; this latter is the maximum (and probably used to but a limited extent). On the whole, however, the result of this comparison is good as far as it goes, and indicates that the former maximum has been used to such an extent as to cease to be exceptional.

In regard to length of rails, there is a surprising unanimity in the adoption of 33-ft. rails. In 1900, only 8 railways reported 33 against 44 reporting 30 ft. as the standard; one reported 30 and 60 ft., and another 45 ft. In 1908, 53 railways report 33 ft., and only two report 30 ft. and 33 ft. four report both 30 ft. and 33 ft. mention is now made of rails longer than 33 ft., which are evidently exceptional and used in special cases. The 60-ft. rails have been objected to as awkward to handle and difficult to maintain in line and surface.

The 33-ft. rails eliminate 10 per cent. of the joints, and are practically no different from the 30-ft. rails as to handling and maintenance. The Am. Soc. C. E. form of section is very generally used, only a few roads reporting other sections, although it must be noted that these lines having special sections represent an extensive mileage. The lightest weight rail in main track ranges from 35 and 40 lbs. (evidently not in important main tracks) to 60 lbs. per yd. A few roads report their standard rails as being the minimum in main track.

As far as quality of rails is concerned, there seem to be general indications (both in wear and fracture) that this has deteriorated rather than improved.

As to rail joints, the tendency is towards short splice bars with four bolts; 40 railways have bars from 24 to 28 ins. long, as compared with 12 having bars from 30 to 36 ins. long and only four have bars from 38 and 44 ins. long. In regard to the number of bolts, 36 railways use four bolts, 19 use six bolts and 2 use both four-bolt and six-bolt splices. The bolt spacing is generally from 4 to 6 ins.; the minimum is 4 ins., while 7-in. and 8-in. spacing is used in a very few cases. The maximum is 9 ins., which is used on only two roads, and is in each case for the outer bolts of a six-bolt joint with 40-in. and 44-in. angle bars. The bolts are ¾-in., ⅞-in. and 1-in. diameter. On many roads a grip thread is used on both bolt and nut, the latter forming a lock-nut and dispensing with the use of a separate nutlock.

Nearly all of the railways reporting lay their rails with broken joints; eight use square joints on tangents and broken joints on curves. The square joint arrangement has been advocated for light track, and the Chicago, Burlington & Quincy uses it with second-hand rails on new unballasted track. This, however, is certainly not standard main-track construction.

The old style of supported joint, with a single tie and short splice bars, is practically obsolete; it is used on parts of the Michigan Central Ry. and the Lake Shore & Michigan Southern Ry., with 23-in. and 24-in. bars respectively. The three-tie joint with long splice bars is used on a few roads, but is not the standard pattern, as a rule.

The two arrangements of joints in most common use are as follows: First, Suspended joints, with rail ends projecting beyond the shoulder ties and spliced by angle bars. In several cases these joints are stiffened by the use of bars having webs which extend below the rail. In few, if any, cases is the base of the rail now supported by a device fitted between the rail and the lower webs of the bars, but not resting upon the ties. Second, Bridge joints, with rail ends projecting as above described, but resting upon bridge plates whose ends are supported on the shoulder ties. These plates are either independent of or integral with the splice bars. The Chicago & Northwestern Ry. has used independent bridge plates for several years. The Chicago, Rock Island & Pacific Ry. has recently adopted a similar arrangement as its standard, but has not yet applied it to any extent. There is a very general use of patented joints of various types, most of which have either a base support or a deep and stiff splice bar (extending below the rail) as the special feature. Some roads report that there is less work of maintenance required with rail joints of the bridge type as compared with those of the ordinary angle-bar type. Such a result would be reasonably expected.

The fastenings of the rails to the ties continue to constitute a decidedly weak and inefficient

feature of the track structure, and show little improvement upon the fastenings used in the early days of railways. In fact, the type remains unchanged, the only improvement being slight modifications in the form of the spike (mainly the use of a sharp point). Probably few outside of the maintenance-of-way department realize the amount of work required in renewing spikes to keep a main track in reasonably good condition under even moderate traffic; or the amount of damage thus done to the ties, and the consequent increased cost and work represented by the tie renewals. The use of tie-plates helps to some extent, since (if they are properly punched) they transmit some of the lateral pressure to the inside spike, while without them the outside spike alone resists this pressure. Where the plate has a shoulder fitting against the outer edge of the rail base, this also distributes the pressure and reduces the necking or cutting of the spike by the rail.

The common spike, 9-16-in. square in the shank and 5½ ins. long under the head, is used almost universally. One railway uses a spike 11-16-in. square. Sharp pointed spikes are quite extensively used, but the practice of curving and grooving the spike to improve its hold in the tie has been given up almost entirely as affording little real advantage. The Michigan Central Ry., however, is experimenting with some channel or grooved spikes. Special forms of fastenings continue to be patented, but rarely get beyond the paper stage.

Of 59 railways, only 8 are experimenting with improved fastenings. These fastenings are screw spikes in all cases, but the experiments are usually on a very limited scale. The most extensive use is reported by the Pennsylvania Lines West of Pittsburg, which system has 25,000 screw spikes. The Atchison, Topeka & Santa Fe Ry. is also about to use them on eight miles of line. The mileage of track on which any form of improved fastenings is used is infinitesimal, even when compared with the mileage of busy main tracks alone. Bolts and clamps are occasionally used on bridges having steel decks. The bolted clamp fastenings used with steel ties are generally efficient in direct holding power, but appear to be deficient in ability to resist lateral thrust. In many cases the bolt bears directly against the back of the bolt hole, and has consequently a small bearing area. In European practice the clamp (or a tie-plate) engages with the hole in the tie and gives an increased area of bearing for the bolt.

Figures as to the life and cost of ties are indefinite and unreliable, usually based upon guesswork and vague averages. Several railways frankly admit that they have no complete or reliable records of this kind, even where treated ties are used. This may appear strange from two very different points of view: First, the importance of ties as a part of the track structure; and, Second, the vigorous way in which attention has been called to the economics of the tie supply question during recent years. It seems that these features are still very imperfectly recognized or appreciated.

Such figures of cost as have been given indicate a decided stiffening of prices. Oak ranges from 60 to 90 cts. (27½ cts. on one road in Louisiana); cedar, 30 cts. to 70 cts.; pine, 45 to 90 cts.; chestnut, 45 to 65 cts. The quality also has doubtless deteriorated. The 8-ft. tie is in most extensive use, 35 railways using this, as against 19 using 8½-ft. ties. Only three report using 9-ft. ties, and this length is not standard, but used in special cases. It is coming to be realized that ties 6 ins. thick are not stiff or rigid enough for the heaviest class of traffic, and there is a general tendency to increase the thickness to 7 ins. Anything more than this is exceptional.

The width is variable; the specified standard is generally 8 or 9 ins., but narrower ties are used. The Duluth & Iron Range Ry. uses ties 6 to 10 ins. wide, but instead of a fixed number of ties per rail it specifies 130 linear inches of tie-bearing to a 30-ft. rail length. The Michigan Central Ry. is also considering the plan of increasing the number of ties per rail (now 18 per 33-ft. rail); the number would be variable according to width of ties, so that in all cases the rail would be supported by the ties for a certain percentage of its length.

Treated ties are used to some extent by nearly 50 per cent. of the railways listed, but in only a few cases have they been used in large numbers, or for a sufficient length of time to enable definite results to be stated. However, the economy of such ties when well treated and properly used has been amply proved. Their more general use as a regular feature of track construction rather than as an experiment is much to be desired.

No mention is made of concrete ties, for while these have been used quite extensively they are merely experimental as yet, and their efficiency yet remains to be proved. In fact, one road which has used large numbers considers them better adapted to sidetracks and yards than to main tracks.

Steel ties also are mainly experimental, and are mentioned by only one railway. The Bessemer & Lake Erie Ry. reports 145,000 steel ties. This road has an extremely heavy ore and coal traffic, and the steel ties have given good results in service. On some parts of the road the steel ties are used exclusively, but in tie renewals they are often inserted to take the place of old wooden ties. The steel ties are used to some extent at turnouts, being made of extra length in the same way as switch timbers. Some of these ties are of trough section, but most of them are of I-beam section and all have bolted clamp fastenings.

The use of metal tie-plates is very general, but would be more effective if combined with the use of screw spikes instead of common spikes. The plates used most extensively are those having flanges or chisel points which enter the wood and make the plate practically an integral part of the tie. Some important railways, however, are reverting to the use of flat-bottom plates, or else plates in which the flanges are only large enough to prevent the plate from slipping on the face of the tie. Screw spikes are particularly desirable for these latter types of plates.

In most designs, the grip of the tie upon flanged tie-plates is confined to the elastic pressure of the fibers against the sides of the flanges. In one design of tie-plate (termed the "fish-hook"), the flanges are of bulb section, having a rib along the lower edge. The ribs or bulbs are embedded in the fibers and thus obtain a positive hold in the wood. The flat-top tie-plate and the tie-plate with a shoulder or rib on the top to fit against the outside edge of the rail base, are used to about the same extent, but there is an evident tendency toward increased use of the shoulder plate. On most railways, the tie-plates are used mainly on curves and on soft ties; also for turnouts.

Of the use of ballast little can be said by way of summary, as the materials continue to be most variable in character, quality and quantity. The term "gravel" covers anything and everything from dirty bank gravel (full of sand or loam, or with a considerable proportion of large stones) to clean washed and screened gravel which is nearly as good as stone ballast.

While the use of stone ballast is reported by many railways, it is very generally confined to comparatively short stretches of busy main track. The new Virginian Ry., however, is using stone throughout; this road is being built for a very heavy coal and freight traffic. The tendency is to use smaller sizes of broken stone than were used some years ago, the purpose of the change being to obtain a denser and more substantial bed of ballast. In some cases, screenings have been applied upon coarse stone ballast. The size of ballast is specified usually for a range of from ¾-in. to 2½-ins., although some roads specify a single size (1½-in., 2-in. or 2½-ins.). Slag does not seem to be used except in the near vicinity of furnace plants, and burned clay appears to be going out of use. The depth of ballast under the ties on main track averages from 8 to 12 ins., but might in many cases be increased to advantage where heavy loads and traffic are carried. A combination is used in some few cases. Thus, on some parts of its line the Michigan Central Ry. uses 6 ins. of 1½-in. stone on 6 ins. of gravel. The Lake Shore & Michigan Southern Ry. also uses 8 ins. of stone (½-in. to 1½ ins. in size) on 12 ins. of gravel or slag. Our inquiry included the character of the stone used for ballast, and in a majority of cases this is reported as limestone. Granite, trap and hard sandstone are also mentioned.

In the matter of turnouts, the bolted type of frog continues to be most generally used. Spring-rail frogs are usually adopted for main-line turnouts where the siding or turnout traffic is relatively small. The frogs for main track are usually Nos. 9 to 12, the higher numbers being for passing sidings. Rigid frogs of Nos. 15 to 20 are often used at junctions and the connections of double-track to single-track sections. For yard work, Nos. 7 to 9 are most commonly used. The Yards and Terminals Committee of the American Railway Engineering and Maintenance of Way Association has formerly recommended No. 9, but this year changed the recommendation to No. 8. The reason given for the change was that the latter takes less room, turns a greater angle, costs less and is equally good from the point of view of yard service. The Pennsylvania Lines use No. 7, and the same is practically standard for all the classification yards around St. Louis. The No. 7 and No. 8 frogs put the leads closer together than where a No. 9 is used, and thus give a shorter distance for the cars to travel in switching. This is of importance in utilizing the available space and in operating the yard. However, No. 7 should be the minimum for yards of modern design.

In regard to the width of flangeway for frogs and guard rails, 38 railways continue to use 1¾ ins., while 18 use 1⅞ ins. and three use 2 ins. The increase from the old standard of 1¾ ins. to 1⅞ ins. is usually intended to provide for the latest wheel design of the Master Car Builders' Association. It has been shown, however, that the increase in thickness of wheel flange below the level of the rail head is very slight, and that the wheels can safely operate in the 1¾-in. flangeway. If any change is to be made, it should first be discussed by the rolling-stock department as well as the maintenance-of-way department, in order that both sides of the question may be given consideration.

The split switch is practically universal as a standard. A few roads continue to use special switches (with unbroken main-line rail) in special cases, but the use of such devices does not appear to be on the increase. The stub switch is practically obsolete for main-track and is rapidly disappearing from yards. It is doubtful if any new switches of this type are being installed. For ordinary turnouts, the 15-ft. switch rail is almost universal, whether for 30-ft. or 33-ft. rails. A few roads using 33-ft. rails make the switch rail 16½ ft. long, and others make the length 18 ft. or 20 ft. Switch rails 20 ft. to 30 ft. long are used in high-speed turnouts. In yards and on unimportant branches or industrial spurs 10-ft. rails are sometimes used.

The tapering switch rail made from an ordinary track rail planed to a thin point and top edge, is universal; but it is very generally reinforced by flat or tee-bars riveted to the web. The German railways have set an example worthy of imitation in using switch rails of an entirely different form, giving greater strength and lateral stability. The section is practically an inverted T; the stem is heavy, with the top planed to form a rib or fin, while the lateral rigidity of the rectangular stem is increased by the bottom flange.

The automatic switch (with spring connection in the head-rod of the switch) has almost disappeared, and where used it is confined to yards or branch lines. As to automatic and rigid switchstands, these are used almost equally, but the latter is gradually superseding the former for main-track switches. In 1900, 24

railways reported the automatic and 23 reported the rigid switchstand as standard; in 1908, the numbers are 23 and 29 respectively.

There has been a marked increase in the use of distant signals to protect main-track switches, aided no doubt by the numerous cases of derailment and collision caused by open switches having no other protection than a common target and lamp on the switchstand. The increase is partly accounted for by the extension of the block system and the use of interlocking plants. Apart from these, however, there is a marked tendency to apply distant signals in connection with ordinary outlying switches, especially where the view is obstructed or other dangerous conditions exist. In view of the increase in density and speed of traffic on many lines not operated on the block system, it is most desirable that a safety device of this kind should be more generally adopted as a protection for trains, pending the introduction of block signals.

Footguards should be used to prevent employees from getting their feet caught under the rail heads in the angles of frogs, the heels of switches and the ends of guard rails. There are numerous fatalities and injuries resulting from men being struck by trains while held in this way. The use of the guards is not so general as it should be, and some railways use them only in states where their use is compulsory. In many modern frogs, the raising block forms an effective footguard at the heel. An iron bar or heavy strap set on edge and bent into a loop which is forced between the webs of the rails, makes an efficient guard. Many railways prefer cast-iron blocks. Wood blocking is efficient when new, but is liable to become worn and damaged, and to be left neglected in that condition. The Hart footguards used by several important lines consist of wooden bars of triangular section fitted against the rail webs as fillers; the inclined face slopes from the bottom of the rail head to the edge of the rail base, thus effectively preventing a man's foot from being caught under the rail head.

Our inquiry included the use of guard rails and transverse tie-rods or tie-bars on curves. These are for the purpose of preventing derailment, the former by guiding the wheels and the latter by holding the rails. The use of these devices is limited, and is confined mainly to sharp curves in yards. In view of the many derailments on curves, the stresses to which the spikes are subjected, and the difficulty and expense involved in maintaining gage on curves, it would seem desirable to place guard-rails and tie-bars on main track curves used by high-speed trains, thus relieving the outer rail of some of the lateral or "bursting" pressure. Home-made bridle rods, consisting of flat bars with the ends bent up to engage the edges of the rail base, are sometimes to be seen at sharp turnout curves in terminals. If the bar is made in two parts, with the inner ends threaded and connected by a turnbuckle, the width of gage can be maintained and adjusted more readily. The Michigan Central Ry. is considering the use of long plates (like the slide plates at switch points) extending under both rails. These would be for curves of over 30°, and it is thought that they would be preferable to tie-rods passed through the webs of the rails, such as are used in street railway track.

Guard rails are, of course, generally used on bridges; they are used sometimes on high embankments, where derailments would be disastrous unless the guards were provided to keep trains from going over the bank. It is strange, however, that many railways in building concrete bridges lay the track level with (or even above) the coping but omit to provide any guard rails. The idea seems to be that such protection is needed only on the open floors of trestles or steel bridges, and not where the regular track construction is carried across a structure. A derailment when crossing (or approaching) a concrete bridge under the conditions noted above would be very liable to result in a serious accident.

Reviewing the situation as a whole, it may be said that the tables show the present standards of track construction to be good as far as they go; but we have already pointed out that they have not yet been applied universally even where fast and heavy traffic is imposed upon the track. The economics of track construction need to be impressed upon those who control the purse strings, and it is to be feared that too many of these gentlemen are more interested in Wall Street than in the science of economical railway transportation.

It is interesting to note that in not a single instance has anything been done towards radical alteration of the system of track construction, the only improvements made being in the detail parts of the structure. A few, very few, experiments with new designs have been made on a small scale, but certainly with no idea of following them up in actual practice.

LETTERS TO THE EDITOR.

Where Should Work be Stopped on a Reinforced-Concrete Beam?

Sir: In a number of buildings now being erected in reinforced concrete I have noticed work stopped over night in the middle of the span, both in slabs and beams.

I have spoken to the foremen and was told that the instructions to do this were given by the engineers for the company. One engineer to whom I spoke defended the practice by saying the work was stopped at a point where the shear was zero; and that as the concrete is in compression, the middle of the span was the best place to stop the work.

If I have been wrong in my practice heretofore in going to considerable trouble, and sometimes expense, to stop work over supports, I would like to know it. Shear may be zero at the exact center of the span but it has some value on each side. I should think also that it would be impossible to effect such a junction of the work when pouring of concrete is resumed next morning that there would be no appreciable joint in the middle of the beam when the load comes on. I should think that there would be an incipient crack at the mid-span just where the greatest section of steel is required and corrosion would set in there readily.

Yours truly,

Chicago, Ill., May 21, 1908. E. M.

[Our correspondent has brought up a question upon which concrete constructors are about equally divided. Up to within the past two years it was the practice in finishing the day's work in beams and girders to stop immediately over the columns, when it was impossible to complete a whole floor, or independent portion thereof, without stopping work. More recently, however, the practice of stopping in the middle of the member has become popular, and is probably now more used than the other. The one great objection to this latter practice is, as noted in the letter, the danger of a crack allowing corrosion in the reinforcement, at the point of its probable highest stress, but in good work the danger of a crack at the bonding point from internal stresses, due to shrinking and temperature, is becoming more and more improbable, and the absence of any material shear at the middle of the beam makes that position the most advantageous for the resisting of structural stresses which would tend to open the crack.—Ed.]

The National Business League of America on the Conservation of Natural Resources.

Sir. Referring to the national "Conference on the Conservation of Natural Resources," recently held in Washington, at which this League was represented, and to the comprehensive and timely editorial in Engineering News of May 21, I enclose herewith copy of resolutions which indicate the position of this organization on the subjects under consideration.

Yours very truly,

A. A. Burnham,
General Secretary.

Chicago Stock Exchange Building, Chicago, Ill., May 25, 1908.

Resolved, That in accordance with the general aim and purpose of said Conference, the Standing Committees of the National Business League of America hereby specially recommend the forwarding of the following economic public measures, of grave importance, as involving the future welfare of the American people:

First. Systematic conservation and reproduction of the forests and creation of forest reserves, for the perpetuity of our water courses, water powers, agriculture, industries and commerce, and for the prevention of disastrous floods and erosion of the soil.

Second. Reclamation of arid lands by irrigation and of swamp and overflowed lands by drainage.

Third. Equitable distribution of arable public lands, in small farms, to home builders only.

Fourth. Husbanding of oil deposits; iron, and other products of the mine.

Fifth. Construction of better common the farms to the mills and markets of creation of a comprehensive system of waterways by the commonwealth and th

Sixth. Co-operation of art with nat the beauty of the landscapes, the nook and to create more healthful conditions

Seventh. Enactment of national statute cover the measures herein recommended all laws in conflict therewith.

Engineering Societies Should be Careful Engineering Literature They Put in

Sir: We may understand "clay wo throwing mud" (Engineering News, April that commercialism pure and simple can in the Boston Society of Civil Engineers a surprise; it not only gets a hearing bu cation of the paper in the "Journal of the Engineering Societies" stamps the facts demonstrated, and as the opinion of all cap I refer to an article read Oct. 16, 1907, in the "Journal of the Association," for D

All concrete not protected by a waterpro worthless, is the gist of the article, and surprising statements will be found if y over it.

Before I had read the article, I was met the partner of a prospective client, with the state that all concrete reinforced with steel is valuele that the steel always rusts, that only for a limite time will such work preserve a semblance of the or al structure, that this is the opinion of one of the most prominent engineers in the country and that all intelligent engineers concur in the opinion. My denial of this wholesale statement promptly placed me outside of the category of "intelligent engineers," and stamped me as either maliciously lying on a subject with which I professed an acquaintance, or as so far behind the literature of the profession that I was unacquainted with a fact well known to all engineers.

At best the securing of work is none too easy for an engineer, and it hardly seems right that an engineering society should by its publications render the task more difficult.

The foregoing is an absolute fact and is written to call attention to the fact that the stereotyped statement that "this society as a body is not responsible for the statements made in papers read before it," actually does not relieve the society from the moral responsibility.

Yours very truly,

Edwin H. Warner.

Union Trust Building, Los Angeles, Cal., April 28, 1908.

[Our correspondent's letter shows how careful engineering societies ought to be as to the quality of the engineering literature which they put into circulation. Mistakes and careless editing not only mislead the public but may result in direct injury to the profession.—Ed.]

Notes and Queries.

Apropos of our remarks last week on notable examples of long tenure of office in engineering positions, we are reminded of a conspicuous example much nearer home than the British case which we cited. Mr. James Owen, M. Am. Soc. C. E., was appointed County Engineer of Essex County, N. J., in July, 1868. He served continuously in that position for 39 years and is now Consulting Engineer for the same county.

F. E. R., Accomac, Va., inquires the cheapest way to build a road across a salt marsh about a mile wide.

This road is to replace an old road built some years ago by throwing up earth from parallel ditches by hand shovels at a cost of $1,100. Part of the road was built on pine slabs or poles, on which marsh turf was thrown, and the top was covered with oyster shells. As the shells are now rather high in price they have not been replaced where worn out, and now the teams hauling over the road often break through the rotten corduroy, which also has been undermined by marsh rats. What is desired is a durable dirt road at the lowest possible cost.

THE PROBLEM OF CAPACITY IN RAPID-TRANSIT SYSTEMS: REPORT OF B. J. ARNOLD ON THE NEW YORK SUBWAY.

In planning for the improvement of passenger transportation in New York City, the State Public Service Commission which has jurisdiction in the city has devoted special attention to the municipal rapid-transit subway, operated by the Interborough Rapid Transit Co. A thorough investigation into the technical details of operation, in so far as they touch the convenience, speed, etc., of service, was early decided upon, and Mr. Bion J. Arnold, of Chicago, Ill., was engaged to make such investigation. Several phases of the resulting study have already been completed and reports thereon rendered to the

commis... These dealt with minor changes, improv... is in the automatic signal system, and in... ements in the arrangement of doors and se... in the cars to promote comfort and capacity.

The ... important question of all, namely, how t... ure maximum passenger capacity so as to ... e the subway of maximum service value, ... been taken up more recently, and a report ... it was rendered only a few days ago.

Impor... nt facts and useful conclusions are presented ... the report. First, it is shown that the New Y... subway is seriously limited in capacity, ... d that this is due both to operating faults ... to imperfections in the original design. S...ond, the factors which determine its capacity ... factors of general bearing in all rapid-transit railway problems—are rather clearly analyze... Third, the extent to which the capacity of the existing subway can be developed is studied. And finally the inherent capacity limits of such rapid-transit railways, irrespective of the design of the present subway, are determined.

The New York subway is grossly inadequate to handle all the traffic offered in the rush hours. The cars are packed with passengers to an intolerable degree, often passing the brutal; the station-platforms being almost as congested as the cars, trains are much delayed at stations, and the capacity is thereby further reduced; and, partly in consequence of this condition, the tracks are often overloaded with trains to such a degree that the progress of a train along the line is a discouraging succession of short runs, jerks and stops, with a low average speed. All these conditions are and have been thoroughly appreciated by New Yorkers, though their underlying causes have not been known. Mr. Arnold brings out the very interesting additional information that not only is the capacity of the system insufficient to carry the traffic offered, but it is insufficient to pay a fair return on the investment. At the uniform 5-ct. fare, the system cannot pay reasonable interest; not because a paying traffic is not there, but because much traffic is turned away during the rush hours on account of the limited capacity of the line.

The total investment required to build and equip the subway as it exists to-day amounts to approximately $75,000,000, of which $50,000,000 may be charged to the cost of the permanent way and $25,000,000 to the cost of equipment.

In 1907 the subway carried 182,000,000 passengers and during the present year it may possibly carry 200,000,000 passengers, resulting in an annual income of $10,000,000.

For the last two years the operating expenses of the subway have amounted to an average of approximately 45% of the gross receipts. On this basis the annual operating expenses, with a gross income of $10,000,000, will amount to $4,500,000, leaving $5,500,000 to be applied toward the payment of interest, depreciation, taxes, sinking fund and profit. This amount is only 7.33% upon the above investment of $75,000,000, and it is thus apparent that the present subway, which is now overloaded, is not built in such a way as to furnish sufficient capacity, with the conditions under which it has to operate, to produce financial results consistent with the investment.

The earlier reports of the present investigation have already showed that the subway (considering only the express tracks, whose capacity determines that of the whole system) is operating something less than 30 trains per hour in one direction, during the rush hours. The capacity aimed at is 30 trains per hour, but it cannot be maintained. The station stops are the limiting factor, broadly speaking, but their effect is heightened by the existence of a double cross-over just north of the 96th St. station, so located that trains are held in the station until the cross-over is cleared for their route. The latter condition will be greatly ameliorated by reconstruction of the trackage at 96th St., to bypass the local trains around the cross-over; this has recently been put under contract by the Public Service Commission. But the delaying effect of the station stops, which will remain in full, is the fundamental difficulty. Mr. Arnold's study has been extensively concerned with the analysis of the influence of station stops and how it may be made less injurious. (See "Types of Rapid-Transit Car for Maximum Service," Eng. News, March 5, 1908, for an analysis of the station stops.) The basal principle in the design and operation of rapid-transit lines, a principle recognized by but few persons hitherto, in spite of its obviousness, finds expression in the report as follows:

> The headway and therefore the capacity of the present subway is governed by the "station headway"; that is, the number of trains is limited by the number that can be passed through the limiting station. The capacity of future subways should be limited only by the number that can safely be passed over the tracks between stations.

The last sentence brings out the principle: All parts of a rapid-transit line should be designed

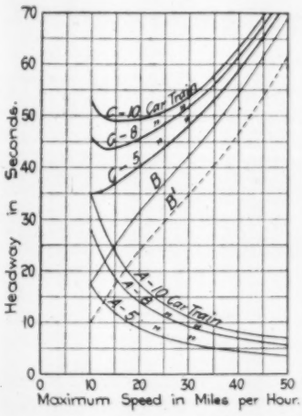

Fig. 1. Minimum Time-Interval of Rapid-Transit Trains on the Open Line.

(Line controlled by overlap block-signals spaced to correspond with maximum speed of train.)
A = Time required to run length of train.
B′ = Time required to run length of block.
B = B′ plus 2½ sec. lag of signal plus 5 sec. time lost between clearing of signal and train passing signal.
C = A + B = Minimum safe spacing.

for equal capacity, in order that no one part shall be a throttling-point; otherwise the investment in the system is not fully utilized and the design therefore is inefficient.

The method of operation, of course, is directly involved in this matter. If the system is operated in such a way as to produce needlessly long station stops, the line capacity is cut down. Conversely, if by improved operating methods the station stops can be shortened, then more trains can be run over the line at the time of maximum demand, and consequently the earnings are increased. It must be remembered that the possible gain is wholly a gain of peak-load traffic, so that any methods which increase the peak-load capacity will tend to secure the only available gain in receipts.

Previous reports of this investigation have suggested methods for reducing the station interval of trains, by improvements in several

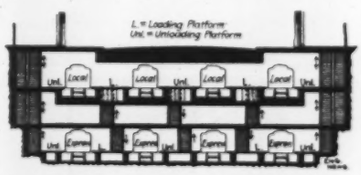

Fig. 2. Arnold's Recommended Design for a Double-Deck Station for Future Subways.

directions: (1) accelerating the passenger interchange at stations, through the assistance of uniformed platform guards, aided by properly-arranged platform railings; (2) changing the present conditions of car loading and unloading, by the adoption of multi-door cars providing for separation of the entering and leaving passengers, and also by provision of separate loading and unloading platforms to keep the two streams of passengers from blocking each other; (3) reducing the dead delay of trains by installing automatic door-closing signals, the motorman being given an automatic electric signal as soon as the last door is closed; (4) spacing trains closer together near stations than on the open line, by some kind of speed-control signal system, so that a train approaching a station will be permitted to approach the train ahead much closer than the block system now permits. Mr. Arnold believes that the adoption of all these changes, together with some minor improvements such as more efficient braking (with a retardation as great as 2½ in place of the present 2 miles per hour per second), will enable the present train capacity to be increased by one-third, i. e., permit 40 trains per hour to be run, instead of 30.

This, however, he sets as the maximum train capacity that can be hoped for without reconstructing the stations. To raise the passenger capacity, he suggests adding two cars to each train, although the station platforms are not long enough to accommodate them. He believes that it will not prove difficult to educate the passengers to the point of recognizing the "through" character of the added cars, and to appreciate the added comfort and capacity gained at the cost of working their way through the crowded aisle of an additional car length when entering and leaving the train. If this is tried, it will doubtless prove an interesting experiment. But the gain is so great, 25% on the express tracks and 40% on the local tracks, as to make the suggestion well worth a trial.

MAXIMUM CAPACITY OF OPEN LINE.—Trains spaced 90 sec. apart, or 40 per hour, represent the capacity of the existing New York subway as limited by the conditions at stations. The track between stations has a greater capacity. The diagram Fig. 1 herewith exhibits the several factors which determine the spacing of trains on the open line, under control of a signal system which holds them to the minimum safe spacing. As the braking distance is greater with greater speed, in the ratio of the square of the speed, while the time required to run through this distance decreases only directly as the speed, the minimum time-spacing necessarily becomes greater as the maximum speed for which the system is designed increases.

The diagram clearly shows that, within the common range of speeds, trains on a rapid-transit line can run somewhat closer than 60 sec. apart on the open line. That is to say the capacity of the track itself is slightly over 60 trains per hour in one direction.

To enable the system to utilize this capacity, evidently, the stations must be designed to permit at least an equal rate of train movement. But, as already mentioned, the requirements of traffic make the station stop so long that no closer train interval than 120 sec. is secured at present, and with Mr. Arnold's suggested improvements this can be reduced only to 90 sec. In other words, a station has only half the train capacity that the open line affords. It follows that the station should be duplexed, in order to bring up its capacity to equal that of the line.

This duplexing is what Mr. Arnold proposes as a necessary feature of all future subways. Two station tracks should be provided for each line track. This may be arranged in a variety of ways, but bearing in mind that two express and two local tracks mean eight station tracks (if the duplexing is also applied to the local tracks, as seems proper), the only feasible scheme is a double-deck station, with four tracks on each level. A number of sketches for such a station are shown in the report. That reproduced herewith as Fig. 2 is recommended as the best.

This plan places a concourse or interchange passage on an intermediate level between a lower level of four express tracks and an upper level of four local tracks. All the platforms are of the island type, and afford easy means of segregating the entering and leaving passengers on separate platforms. This last is unquestionably a requisite of primary importance in rapid-transit stations, for the conflict of the opposing streams of passengers entering and leaving a train is a vital factor in limiting the capacity. At the same time it is not desirable to make the exits from the unloading platforms lead directly out of the station, as this renders it impossible to transfer from one train to another. But transferring, in the experience with the New York subway, has proved to be a fea-

*The report on cars was abstracted in our issue of March 5, 1908, p. 262, under the title "Types of Rapid-Transit Car for Maximum Service."

ture of such value that due regard for the needs of the public would reject any plan lacking the transfer facility. The plan shown by Fig. 2 provides in the simplest manner for this transferring, as all the platform stairs lead from and to the concourse or interchange passage. The stairs from the surface to this concourse are located at the extreme side of the station, and could therefore be located either on a lateral street or on private property. Mr. Arnold expresses preference for the latter disposition.

Such a duplexed station, or "reservoir" station (as it is called in the report because with reference to trains it forms a reservoir in the track system), should have a capacity nearly twice that of a station as now built. That is, compared with the capacity now secured in the New York subway, it should be able to handle 60 trains per hour; when compared with Mr. Arnold's promised figure of 40, it should handle 80 trains per hour. This compares well with the capacity of the open line, and would thus meet the specification that the stations should have a capacity equal to that of the line.

CONCLUSIONS OF THE REPORT.—The capacity studies lead Mr. Arnold to the following specific conclusions, most of which state in brief form what has been explained in the preceding abstract:

(1) The present subway, though carrying more passengers than it was originally designed to handle, lacks sufficient passenger carrying capacity under the conditions that it is now operating to pay a fair return on the investment and at the same time allow for a suitable depreciation reserve.

(2) The present subway is also defective in not having sufficient passenger carrying capacity to take care of the demands of transportation along its route during the two rush-hour periods of the day; that is, the subway is lacking in what might be termed overload capacity.

(3) The headway and therefore the capacity of the present subway is governed by the "station headway"; that is, the number of trains is limited by the number that can be passed through the limiting station. The capacity of future subways should be limited only by the number that can safely be passed over the tracks between stations.

(4) The present rate of train movement of 30 trains per hour in one direction upon each track can be increased to 40 trains per hour by

(a) Installing automatic closing door signals upon the cars;

(b) Providing speed control signals auxiliary to the present block signal system at the approaches to the stations;

(c) Altering the cars to provide more doors in the sides of each car.

These changes have been discussed in detail in Reports Nos. 1, 2 and 3.

(5) To most effectively secure the benefit of these changes the cross-overs in the tracks north of 96th Street station should be removed in accordance with the plans which have already been approved by the Public Service Commission.

(6) The 96th Street changes can be made still more effective by adding to these plans the feature of double-decking [of the local tracks, using the upper or present local tracks for express trains.—Ed.] thus providing two additional express tracks in the station.

(7) To secure the same capacity for the Brooklyn extension that will eventually be obtained for the Manhattan subway, a plan for handling the South Ferry passengers should be worked out so that all express trains can be run through the Brooklyn tubes, thus increasing their present capacity at least 33%.

(8) The train capacity of the subway cannot be increased by increasing the speed of the trains, as the increased length of the signal blocks necessary for the higher speeds more than offsets the advantage of the increased speed.

(9) The capacity of the subway can be increased by greater care in using the brakes at the stations. Very little effect upon the capacity can be expected by improving the acceleration of the trains.

(10) Considerable improvement in the capacity can be secured by running longer trains and a movement in this direction should be started as it will eventually be found desirable to run 7-car local trains and 10-car express trains, both at the rate of 40 trains per hour. When this is done the capacity of the present subway will be increased 75%, which is the maximum increase in capacity of the present subway that can be expected without double-decking the stations which for reasons previously given seems to be prohibitive.

(11) While double deck cars in subways are impracticable, the possibility of using wider cars should be thoroughly considered in making plans for future subways, as there is apparently no difficulty in the way of using wider cars for such subways except the question of transferring the equipment between the present subway and future ones.

(12) To secure the maximum possible capacity of future subways, tests should be made to determine more accurately than has been done, the braking distance required to bring a subway train to rest from full speed when the emergency stop is used.

(13) An improvement in the block signal system which will have a material influence upon increasing the capacity of future subways can be secured by developing a traveling caution signal to act in conjunction with the present fixed one.

(14) Moving platforms have practically double the seating capacity of 10-car trains running upon 60-sec. headway, but on the other hand these moving platforms

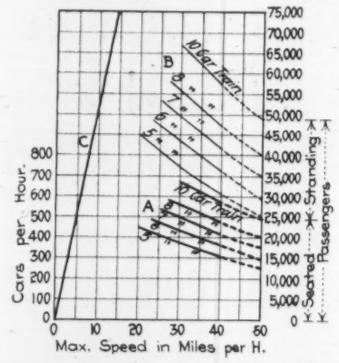

Fig. 3. Maximum Hourly Capacity of a Rapid-Transit Line, and Capacity of a Moving Platform in One Direction.

Note: The train curves terminate at the left at such a speed as make the minimum block (⅛ the braking distance) equal to length of train. As the blocks cannot be made shorter, there is no gain in capacity at lower speeds.

A = Car and seating capacity (50 passengers per car).
B = Passenger capacity on basis of 100 passengers per car.
C = Moving platform, passenger capacity on basis of one seat per lineal foot of platform.

have a speed of only one-half the schedule speed of the train, and therefore the train method of operation is to be preferred for long distances.

(15) In order to secure maximum capacity for future subways these subways should be designed with double-decked stations provided with double tracks for each main line and the cross section of the subway between stations should also where practicable be doubledecked; this plan will allow the operation of 10-car trains on a 60-second headway on each track, thus providing a carrying capacity of three times that of the present subway.

Recommendations for action by the Public Service Commission are made in accordance with the preceding conclusions, except (15). They look toward a capacity, in one direction, of 40 express trains per hour, 10 cars each, or 400 trains per hour, which gives roughly 20,000 seats, or with cars loaded to 125 (as on the average in the rush hours), a capacity of 50,000 passengers per hour.

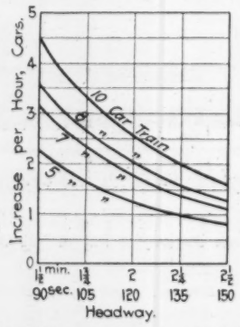

Fig. 4. The Value of One Second in Relation to Capacity of Rapid-Transit Lines.

(Increase in car capacity of line for one second decrease in train spacing.)

The local tracks are to have a capacity, in one direction, of 40 7-car trains per hour, or 280 cars, or with an average loading of 75 passengers, 21,000 passengers per hour. Since most of the rush-hour passengers in local trains change to express trains, the total capacity of the system in the rush hours will not greatly exceed the express-track capacity, or say 60,000 passengers per hour, which is about 75% greater than the present capacity.

Two of the illustrations accom[pany] the report are of special interest, apart[from] the particular conclusions reached. Th[ey] are reproduced here as Figs. 3 and 4. F[ig. 3] shows the hourly capacity of a rapid-tran[sit] line, in one direction, one track, based on the [maxi]mum train interval fixed by conditions on th[e] line (see Fig. 1). Two sets of curves are s[hown], of which the lower, for 50 passengers per [car] represents the hourly seating capacity, while [the] upper, for 100 per car, represents the total [ca]pacity when the cars are fairly well crowded [with] standees.

As will be seen, the capacity d[oes] not increase as the maximum speed of trains increases [for] a fact which will be understood by referring t[o the] curves C in Fig. 1. A different type of [trans]portation medium, the moving platform, has [the] opposite characteristic, since its capacity [in]creases directly with speed of movement. [The] capacity curve for a moving platform is shown by the straight line in the left-hand part of Fig. 3. This is based on a seating capacity of 1 per lineal foot of platform, or 5,280 seated passengers per mile. At a speed of 10 to 12 miles per hour, the platform has a capacity about equal to that of a well-operated rapid-transit line running 10-car trains, and the passengers on the former are all seated while half of the train passengers must stand. But the platform transports these passengers at the speed of only 12 miles per hour, as compared with an average of 25 to 30 for the trains. The possibility of higher speeds for moving platforms is not discussed in the report, and in fact the subject is not pursued farther.

Fig. 4 is the other diagram of special interest. It represents the gain or loss in capacity produced by a decrease or increase of one second in the train spacing. The abscissas are the time-spacing of trains, while ordinates represent gain or loss, in cars per hour. Expressing the contents of the diagram analytically, we would find that the gain or loss of capacity for unit variation of train spacing varies inversely as the square of the spacing; that is, at 60 sec. spacing the gain or loss by changing to 59-sec. or 61-sec. spacing is four times as great as the gain or loss in changing from 120-sec. spacing to 119 or 121. The percentage gain or loss varies directly as the inverse of the spacing, the gain or loss per cent. at 60-sec. spacing being twice as great as at 120-sec. spacing.

The value of the diagram lies in bringing clearly before the eye the increased importance of preserving minimum spacing as that minimum itself becomes smaller. When the present subway is raised from 30 to 40 trains per hour, it will be about twice as important to watch the seconds in train spacing, and even the *relative* importance of each second will be increased 33%.

ANNUAL MEETING OF THE NATIONAL FIRE PROTECTION ASSOCIATION.

The 12th annual meeting was held at Chicago, May 26 to 28, in the assembly room of the Chicago Board of Underwriters. The chair was taken by the Vice-President, Mr. Wm. A. Anderson. At the opening session on Tuesday morning, May 26, a brief address was made by Mr. Anderson. A report of the work done by the staff of the new "Quarterly," which takes the place of the former bulletins of the association, was presented. This work includes the preparation and filing of fire records, as well as the publication of the "Quarterly." Some changes in the articles of association were adopted. The most important of these was to include "fire prevention" as well as "fire protection" in the statement of the objects of the association. Mr. W. H. Merrill presented his report as Secretary and Treasurer. It showed a membership of 1,341, and a balance of about $1,934 the receipts and expenditures for the year very nearly balanced each other, approximating $12,000 each. The Executive Committee presented an important resolution in regard to the lack of efficient legislation for fire protection. The seconder of the motion stated that he had been endeavoring for years to secure the passage of proper ordinances in his own city, but that they were simply pigeon-holed by the municipal authorities. The resolution was adopted by unani-

mous [illegible], and it was also voted that steps should be taken to give it as wide publicity as possible. The resolution was as follows:

"The National Fire Protection Association, representing all the national institutes, societies and underwriting organizations in the United States which have thus far evidenced their interest in the protection of life and property against loss by fire, through joining its efforts for the general good, has its attention called at this its twelfth annual meeting, to the disasters by fire which have occurred during the past year, involving a great sacrifice of life and an enormous fire waste, as illustrated by Collinwood School, Boyertown Theater and Chelsea and Atlanta conflagrations.

"These, following the previous experiences at Baltimore and San Francisco, again serve to emphasize the apparent disregard on the part of the general public, resulting in the loss of hundreds of lives annually and a fire waste of almost a million dollars for every business day.

"It is believed that the time has properly arrived when adequate laws, Federal, State and municipal should be enacted and enforced in such a manner as will unquestionably check the enormous inroads upon the material resources of our country."

"Therefore, the National Fire Protection Association, in convention assembled, unanimously places itself on record as believing:

"1st.—That a practical means for the conservation of the natural resources of our country is to be found in the restriction of the destruction of property by fire.

"2d.—That State legislation, where not now existing, should be enacted at an early date, enabling communities to make proper provision for the supervision and control of building construction and installation of adequate fire protection and prevention measures.

"3d.—That communities already authorized to enact building laws should give their earnest attention to such revision of present ordinances and adoption of new measures as experience has demonstrated to be necessary and advisable.

"4th.—That buildings where people congregate, such as schools, colleges, theaters, hospitals, asylums, churches, department stores and the like, are peculiarly susceptible to calamitous conditions and should receive the particular attention of the recognized authorities in the insistence upon superior construction and the introduction of apparatus for the automatic extinguishment of fires."

The report of the Committee on Special Hazards and Fire Record outlined the work of the committee in securing articles and special reports on important subjects. It also presented a review of the fire record. In 47 cases (or about 6%) of the fires where sprinkler apparatus was installed this apparatus was unsuccessful in holding the fire in check. In 13 of these cases the water had been shut off temporarily, showing the importance of keeping the pipes clear and of doing repair work as rapidly as possible.

Mr. H. A. Fiske (Hartford, Conn.), chairman of the committee, presented a report on the construction and protection of metal-working plants. While this made a special classification of such plants as rolling-mills, foundries and forge shops, the opinion was expressed in the discussion that further distinction should be made between plants for heavy and light work which were covered by the main part of the report.

A sub-committee has made a progress report on denatured alcohol. Another sub-committee started to present a report on nitro-cellulose products, but it appeared that the members of the sub-committee had not unanimously approved it. Under the rules of the association, therefore, the report could not be presented at the meeting. It was presented, however, at a later session, the committee having settled its differences of opinion.

The Committee on Devices and Materials presented specifications for large chemical extinguishers mounted on wheels for use in buildings. The liability of danger from the sudden generation of high pressure when the acid is discharged into the water was referred to in the discussion; also the importance of limiting the width so that the machine can pass through ordinary doorways. The Committee on Automatic Sprinklers reported that it had no changes in the rules to suggest. It was voted, however, that galvanized-iron fittings need not be required.

The Committee on Fire Protection Coverings for Windows and Doors presented through Mr. W. C. Robinson (Chicago) a verbal report. This suggested the advisability (as shown in tests) of making a vent hole in the tin covering of fire doors, in order to relieve the pressure of gases generated by the heat. Under the present construction, doors subjected to intense heat have the sheathing ruptured by this pressure. The suggestion is to provide a 3-in. opening in the sheathing on the exposed side of the door, this to be covered (to exclude moisture) by a tin-plate attached with solder, so as to drop off when attacked by fire. The tests have shown that a door made in this way is less liable to warp away from the wall than a door made in the ordinary way; also that the gases passing out of the aperture effectively protect the wood exposed at the opening. The committee is also considering automatic devices for closing both swinging and sliding fire-doors.

The Committee on Hose, through Mr. H. W. Forster (Philadelphia), presented a report on hose for fire department use, and estimated that the annual consumption of such departments is about 1,500,000 ft. New York is the only large city using rubber hose extensively. There is general need for uniform specifications, and there seems to be great laxness on the part of cities in enforcing guarantees. This latter condition is one reason why hose can be sold at low prices. The report presented a draft of specifications for rubber and rubber-lined hose.

Two reports of the committees on Fireproof Construction and on Concrete and Reinforced Concrete for Building Construction were then read by Mr. E. T. Cairns (New York), who is chairman of both committees. The first of these referred to the probability of arranging a conference of representatives of engineering, architectural, building and fire-protection associations to formulate rules regarding fireproof construction. We shall print abstracts of these reports. The last report of the afternoon session was that of the Committee on Automobile Garages, which was read by Mr. Alfred Stone (Providence, R. I.). It presented detail rules as to the construction and equipment and the methods of operating the equipment, especially in regard to the safe storage and handling of volatile inflammable liquids. Various points were discussed, but action was deferred to give opportunity for hearing representatives from automobile manufacturers.

On Wedesday, 27th, almost the entire morning session was occupied by a discussion of the report of the Committee on Uniform Requirements. This was read by Mr. Gorham Dana (Boston). It presented a number of changes in the requirements for construction as already adopted, and several of these led to criticism and discussion. The requirements as to bearing walls were, with some other matters, referred back to the committee. As presented, they required a thickness of 12 ins. in the top story and 4 ins. additional for each succeeding story. Mr. Stone (Providence, R. I.) pointed out that this would mean a 32-in. wall in the first story of a six-story building. This he characterized as absurd, whether considered as to strength or as to fire protection.

The only other matter presented at this session was a paper by Mr. R. H. Newbern on "Fire-Fighting Equipment for Tug Boats." He suggested the value of such equipment in rendering the boats available for fire service in lake and ocean ports. The paper included detail recommendations as to the equipment required.

At the afternoon session, the committee on Car Houses presented a report outlining the work done in conjunction with a committee of the Street and Interurban Railway Association. Specifications have been prepared for buildings of a variety of types, including both steel-frame and reinforced concrete construction.

The Committee on Roofs and Roofings presented, through Mr. A. P. Stradling (Philadelphia), a report suggesting certain changes in the present rules and specifications on these subjects. The report of the Committee on Pumps was of a similar character. One suggested change was to permit the use of machine-molded gun-iron for gears. As to this the following statement from a pump manufacturer was submitted:

For an installation driven by spur gears and clutch we feel that the use of cut gears is almost prohibitive as to cost in many cases, owing to the large gear required on the jack shaft. It would seem as if a machine-molded gun-iron gear would be the proper thing for this case. A cut gear of cast iron in such sizes and pitches of teeth as it is practicable to manufacture would not equal in strength the perfectly molded gun-iron gears which it is possible to buy to-day.

The Committee on Standard Hose Couplings and Hydrant Fittings for Public Fire Service reviewed the work of the committee in bringing these standards to the notice of municipal authorities and civic associations (boards of trade, etc.) throughout the country. The Committee on Pneumatic Conveyors of Stock and Refuse reported progress.

The report of the Committee on Pipe was read by Mr. A. Blauvelt (Chicago). This included both cast and wrought irons for mains and for sprinkler service. Also pipe fittings and joints, and pipe protection and testing. In regard to cast-iron pipe, Mr. Blauvelt explained that the expected agreement between the New England Water-Works Association and the American Water-Works Association as to uniform specifications had not been effected (Engineering News, May 21, 1908). He suggested that the committee should take the matter up with these associations.

At the close of the session, Mr. W. E. Higbee referred to the failure of the daily press to print or even mention the important resolutions adopted the previous day in regard to the necessity for legislation and building ordinances which will tend to check the present enormous loss of lives and property by fires. It is a matter of vital public importance, but receives scant attention. On the other hand, one daily paper recently published an important article on fire losses, based upon an address made by the president of one of the underwriters' associations. He moved that this should be printed in the proceedings, and this was passed by unanimous vote.

On Thursday, May 28, reports were made by the members delegated to attend the annual meetings of the American Society of Mechanical Engineers, American Water-Works Association, American Street and Interurban Railway Association and the associations of fire department engineers, warehousemen, cotton manufacturers, etc.

A silver cup was presented to the Vice-President (and presiding officer), Mr. Wm. A. Anderson, and in view of his expressed desire to retire from active work in the association, with which he has been connected for many years, he was elected Honorary Vice-President. The officers elected for the year 1908-09 are as follows: President, C. M. Goddard; Vice-President, H. C. Henley; Chairman of Executive Committee, H. L. Phillips; Secretary and Treasurer, W. H. Merrill, Chicago.

THE WRECK OF THE OREGON EXPRESS, on the Southern Pacific, which was derailed, May 21, near Pinole, Cal., is, upon investigation by the railroad board of inquiry, attributed to the breaking of column bolts in the arch bar in the rear truck of the tender, letting the truck down upon the track. Five deaths and two cases of serious injury are now reported as total casualties in the wreck.

A DAM FAILED AND WRECKED A TRAIN near Port Arthur, Ont., on May 27. The dam was on Current River and supplied power to the Port Arthur municipal plant. The city's electric light and water systems were crippled in consequence. The waters released by the dam washed out a section of the Canadian Pacific railway embankment, which caused the wrecking of a freight train shortly afterward. Five persons were killed in the wreck. The loss to Port Arthur is estimated at several hundred thousand dollars.

EXCAVATION OF SUBMERGED REEFS AT Hell Gate, in the East River, New York, will be begun this month by the engineer corps of the army. Flood Rock, at present only 18 ft. under water, is the principal menace to navigation at this point, and as lately as May 24 caused a serious accident, breaking the back of the "H. M. Whitney," which went aground. This is to be excavated to a depth of 26 ft. A total of four acres at the Frying Pan, off Ward's Island, and three-fourths of an acre at Pot Rock, must be deepened.

THE CUNARD TURBINE LINER "MAURETANIA," although handicapped by a broken propeller, made three new transatlantic records during the westward passage, completed June 1. She covered the long course of 2,890 miles, from Daunt's Rock at Queenstown to Sandy Hook Lightship, at an average speed of 24.86 knots per

hour, which gives a total calculated time for the trip of 4 days, 20 hrs. 12 min., beating the record of her sister ship, the "Lusitania," over the same course by ten minutes. During the 25-hour day, ending May 31, 635 miles were logged, averaging 25.4 knots for that time. This performance follows within twelve days of the "Lusitania's" remarkable trip on which the latter made a single day's run of 632 knots, covered the long course of 2,800 miles from Daunt's Rock, near Queenstown, to Sandy Hook lightship in 4 days, 20 hours and 22 minutes, and maintained an average speed for the whole voyage of 24.83 knots per hour.

THE COST OF COAL IN LIVES was entered in the Congressional Record, May 19, by Congressman Cooper, of Uniontown, Pa., when he adduced statistics in support of a bill appropriating $150,000 for an investigation of mine disasters. Pennsylvania's production of bituminous coal was stated as 149,559,047 tons, of anthracite, 76,836,082 tons, at a total expenditure in human life of 1,514. The rapid increase of fatalities in the bituminous districts from 200 in 1898 to 806 in 1907, and from 411 to 806 in the anthracite counties during the same time, demonstrates, according to Mr. Cooper, an urgent necessity for the adoption of preventive measures.

FACING-POINT SWITCHES to the number of 1,078 were removed from the tracks of the Pennsylvania Railroad (lines east of Pittsburg and Erie) during the four years from Jan. 1, 1904, to Jan. 1, 1908, according to a recent compilation by the company. These were for the most part hand-operated switches, of which 743 were taken out entirely and 125 others replaced by trailing switches. Of interlocked facing-point switches, 198 were taken out and 12 changed to trailing. During the same period, however, 1,094 facing-point switches were added, but these are all interlocked. These correspond to a growth of over 500 miles of running track (7,599 to 8,114), with 409 new siding connections.

CONTRACTS FOR ANOTHER RAPID-TRANSIT SUBway in New York City were let by the Public Service Commission of the First District, New York State, on May 22. This new subway is in Brooklyn borough, extending along Fourth Ave., from the Manhattan Bridge (now being built) to Forty-third St., about 3½ miles. The successful bidders are: Section 1, James P. Graham; Sections 2 and 3, William Bradley; Sections 4 and 6, E. E. Smith Contracting Co.; Section 5, Tidewater Building Co. and Thomas E. Bryson. The total of the contract prices for the entire work is about $16,000,000, of which about $1,000,000 is for pipe-galleries. The beginning of work on the contracts is likely to be much delayed, however, by the absence of available funds, the city's debt being very close to the constitutional limit.

AN UNDERGROUND LOOP TROLLEY TERMINAL at the west end of the Williamsburgh Bridge across the East River at New York City was opened to traffic on May 19. This will make the trolley service across the bridge contrast still more with that across the Brooklyn Bridge. On the latter, trolley cars enter from Brooklyn only, and they turn around a series of surface loops on the main floor of the bridge at the Manhattan end, all passengers being discharged and taken on at this point. The Williamsburgh Bridge carries cars from Manhattan as well as Brooklyn, on separate tracks; the former turn at the Brooklyn end, the latter at the Manhattan end. The interchange of passengers at the ends of the bridge is greatly reduced by this means. By putting the Manhattan terminal loop underground, both safety and expedition are furthered very considerably. This underground terminal is also designed to serve as terminal of a future connecting subway between the Manhattan ends of the Brooklyn and Williamsburgh bridges, carrying trains of the Brooklyn Elevated Railway system.

A HIGH RATE OF PROGRESS was attained in the headings of the Loetschberg Tunnel, Switzerland, during April, 1908. The advance of the south heading during that month (28 working days) is within 5% of the record established in the Simplon Tunnel, when 685.5 ft. was driven in a single heading in one month. The Loetschberg figures for April are 656 ft. for the north heading and 521¼ ft. for the south heading, a total of 1,178¼ ft. The two headings have now penetrated, respectively, 6,086 ft. and 5,658 ft. into the mountain, a total of 12,644 ft.

A SLIDE IN THE CULEBRA CUT.—On the east bank of the Canal at Paraiso, the old slide, that probably dates from the days of the French company, is again active. The break became noticeable early in April, and at present a 70-ton and 90-ton shovel are kept busy handling the dirt that creeps down the hill in such great quantities that its progress is noticeable from day to day. If the unusually heavy rainfall continues, the engineers feel it will be a hard fight to keep the loading tracks clear for operating the dump trains, although the problem presented is merely that of removing the dirt as fast as it slides towards the track. The limits of the old slide are 600 ft. back from the east line of the Canal and 500 ft. back from the steam shovel cut. It is believed that removal of dirt from the toe of the hill by the steam shovels caused the surface dirt to slide on its bed of rock and that the heavy rains accelerated its progress. The new slide extends only 200 ft. back from the line of the steam shovel cut and is 500 ft. long. At present about 25,000 cu. yds. of earth are sliding, but if continuous rains should start the whole mass within the limits of the old break, 100,000 cu. yds. would be sliding toward the Canal.—"Canal Record," May 20.

PANAMA CANAL EXCAVATION DURING MAY was quite markedly diminished by the heavy rainfall of 14.64 ins., as against 1.9 ins. for April and 0.99-in. for March. The total excavation for the 25 working days of May was 2,703,923 cu. yds., or a daily average of 108,157 cu. yds., as against 3,296,096 cu. yds. for the 25 working days of April, a daily average of 131,844 cu. yds. The maximum monthly excavation since the American occupation was 3,480,270 cu. yds. in the 26 working days of March, 1908, a daily average of 133,856 cu. yds. The detail figures in cubic yards for the April and May excavations are as follows:

	May.	April.
Steam Shovels:		
Culebra Division	930,179	1,170,872
Gatun Locks	138,815	196,109
Chagres Division, Mindi, Miraflores and Cardenas Hill	362,404	500,460
Dredges:		
Colon Division	564,386	496,366
La Boca Division	530,466	676,539
Total, Canal Prism	2,526,250	3,040,366
Accessory works outside the Canal Prism	177,673	255,730
Total Excavation	2,703,923	3,296,096

It may be noted that the excavation for May, 1907, under similar climatic conditions, was 1,017,659 cu. yds.

AN AEROPLANE FLIGHT OF 12,750 meters (about 8 miles) by Mr. Leon de la Grange, at Rome, Italy, is reported in foreign news despatches as having been made on May 30. The time is stated as 15 min., 26 sec. This performance then holds the record for officially recorded flights with such machines. On April 11 Mr. de la Grange made 3,925 meters (2.5 miles) in 6 min., 30 sec., near Paris, breaking the record of Henry Farman, who won the Deutsch-Archdeacon prize by covering a circular course some 1,300 meters long. This latest record is still far below that of 21.5 miles in 38 minutes claimed by Messrs. Orville and Wilbur Wright as made near Dayton, Ohio, in 1905.

PERSONALS.

Mr. John Ericson, M. Am. Soc. C. E., City Engineer of Chicago, has been offered the position of Director of Public Works of the City of Stockholm, Sweden.

Mr. James S. Watson, Manager of the Drive Chain Department of the Link-Belt Co., has been transferred to the company's chain manufacturing plant at Indianapolis, Ind.

Mr. James L. Bruff, Superintendent of Construction, Turner Construction Co., has been appointed Manager of the recently established branch office of this firm at Buffalo, N. Y.

Mr. H. P. Parrock, formerly Chief Engineer of the Youngstown Foundry & Machine Co., Youngstown, Ohio, has been appointed Chief Consulting Engineer for William B. Hough Co., Chicago.

Obituary.

William A. Pearson, chief architect of the General Electric Co. at Schenectady, N. Y., was stricken with paralysis, May 25, and died the next day. He had been connected with the Schenectady plant for ten years.

Francis Hughes Webb, Secretary, 1878-98, Institution of Electrical Engineers of Great Britain, died May 17. He had retired from the secretaryship on account of advancing years, and lately celebrated his eighty-fourth birthday.

Rear-Admiral Jackson McElmell, retired, Second Assistant Engineer in the Navy in 1860, died at his home in Philadelphia, May 31, at the age of 74 years. He served on the "Niagara" on special duty in laying the first Atlantic cable.

Prof. W. W. Anthony, M. Am. Inst. El. E., Professor of Electrical Engineering at the Cooper Institute, of New York City, died May 29 of heart trouble. He was born at Coventry, R. I., in 1833. He was the author of "Lecture Notes on Theory of Electrical Measurements" and co-author with Prof. C. F. Brackett of a "Manual of Physics."

Rear-Admiral A. S. Crowninshield, U. S. N., retired, died May 27 at the age of 72 years, at Philadelphia, Pa. He graduated from the Naval Academy with the class of 1860 and participated in both attacks on Fort Fisher in 1864-5. In 1897 he became Chief of the Bureau of Navigation of the Navy Department, a[during the] Spanish-American War was a member o[f Board of] Naval Strategy. He retired in 1903.

Frank B. Stevens, a civil engineer, [also as] the inventor of the "Stevens Cut-Off," [was suc-] cessfully applied to the steamboat "Al[bany,] died May 24, at his residence at Castle[ton,] at the age of 94. Mr. Stevens surveyed [in 1890] part of the Pennsylvania Lines between [Jersey City, N. Y.,] Trenton, N. J. In 1891 Stevens Institute [is now a] him the degree of Doctor of Engineering. [Hoboken and] conferred on

Professor Dr. Herman Wedding, Hon. M[. Inst. M.] E., one of the most eminent authorities on [metallurgy in] the world, died May 6, at his home in Be[rlin, Germany.] Dr. Wedding was born in 1834 and devo[ted his whole] life to the mining and metallurgical indus[try, making a] specialty in his later years of iron an[d steel. The] highest honors within the gift of his go[vernment and] technical co-workers were accorded him [in acknowledg-] ment of meritorious achievements as engi[neer, lecturer] and writer; his word was authoritative in [international] metallurgy. Among his widely studied w[orks are the] "Handbook of the Metallurgy of Iron," [a translation] and recasting of Dr. John Percy's "Metall[urgy of Iron] and Steel," and "The Iron Industry."

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
June 9-11. Annual convention at Toronto, Ont. Secy., Richard Moldenke, Watchung, N. J.

MASTER CAR BUILDERS' ASSOCIATION.
June 17-19. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 22-24. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 23-26. Annual convention at Denver, Colo. Secy., C. W. Hunt, 220 West 57th St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
June 23-26. Annual convention at Detroit, Mich. Secy., C. W. Rice, 29 West 39th St., New York City.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 23-26. Annual meeting at Detroit, Mich. (In connection with convention of American Society of Mechanical Engineers.) Secy., A. L. Williston, Pratt Institute, Brooklyn, N. Y.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 23-27. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 29-July 2. Annual convention at Atlantic City, N. J. Secy., Ralph W. Pope, 33 West 39th St., N. Y.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
July 24-25. Summer meeting at Niagara Falls, N. Y. Secy., W. M. Mackay, P. O. Box 1818, New York City.

WESTERN SOCIETY OF ENGINEERS.—A special meeting was held May 18 at the Society's rooms in Chicago, With Mr. W. H. Finley in the chair. A paper on "Steel Rails for Present Service; their Manufacture and Failure," was presented by Dr. P. H. Dudley, of New York.

ENGINEERS' CLUB OF PHILADELPHIA.—The last meeting of the club before the summer recess will be held June 6. The "Elevation of the Philadelphia, Baltimore & Washington R. R. Co.'s tracks through Wilmington, Del." will be described by H. S. Righter, and Mr. Myron H. Lewis will read a paper on "Waterproofing—An Engineering Problem."

THE NATIONAL IRRIGATION CONGRESS.—The Irrigation Congress to be held at Albuquerque, N. Mex., Sept. 29-Oct. 3, is expected to surpass all previous meetings of this organization. It is reported that Vice-President Fairbanks and five members of the cabinet will attend, and the presence of President Roosevelt is hoped for. Besides irrigation, other subjects of discussion will be the Forest Service, the Department of Agriculture and the U. S. Reclamation Service. An exhibition comprising products of Indian handicraft, agricultural machinery and irrigated land produce will be held. The town of Albuquerque is building a steel, brick and concrete hall with a seating capacity of 4,000.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION.—The Master Boiler Makers assembled in Detroit, May 26 for their first annual meeting. The present membership of this new association is given as 337. Among the remarks made by President Wagstaff in his address of welcome was the following:

> Much skill has been exercised by the designing engineer in perfecting the triple and quadruple expansion engines; much has been accomplished with the steam turbines; much has been done in harnessing the various water powers of the world, but when we get down to nature, it will be found that the final link between the energy in the coal pile, and its transformation into useful work is our old friend, the steam boiler.

The officers are: Pres., George Wagstaff; Secy., Harry D. Vought; Treas., Frank Gray.